THE PRODUCTION ENGINEER

THE [illegible] OF THE INSTITUTION OF PRODUCTION ENGINEERS

JULY 1960

THE PRODUCTION ENGINEER

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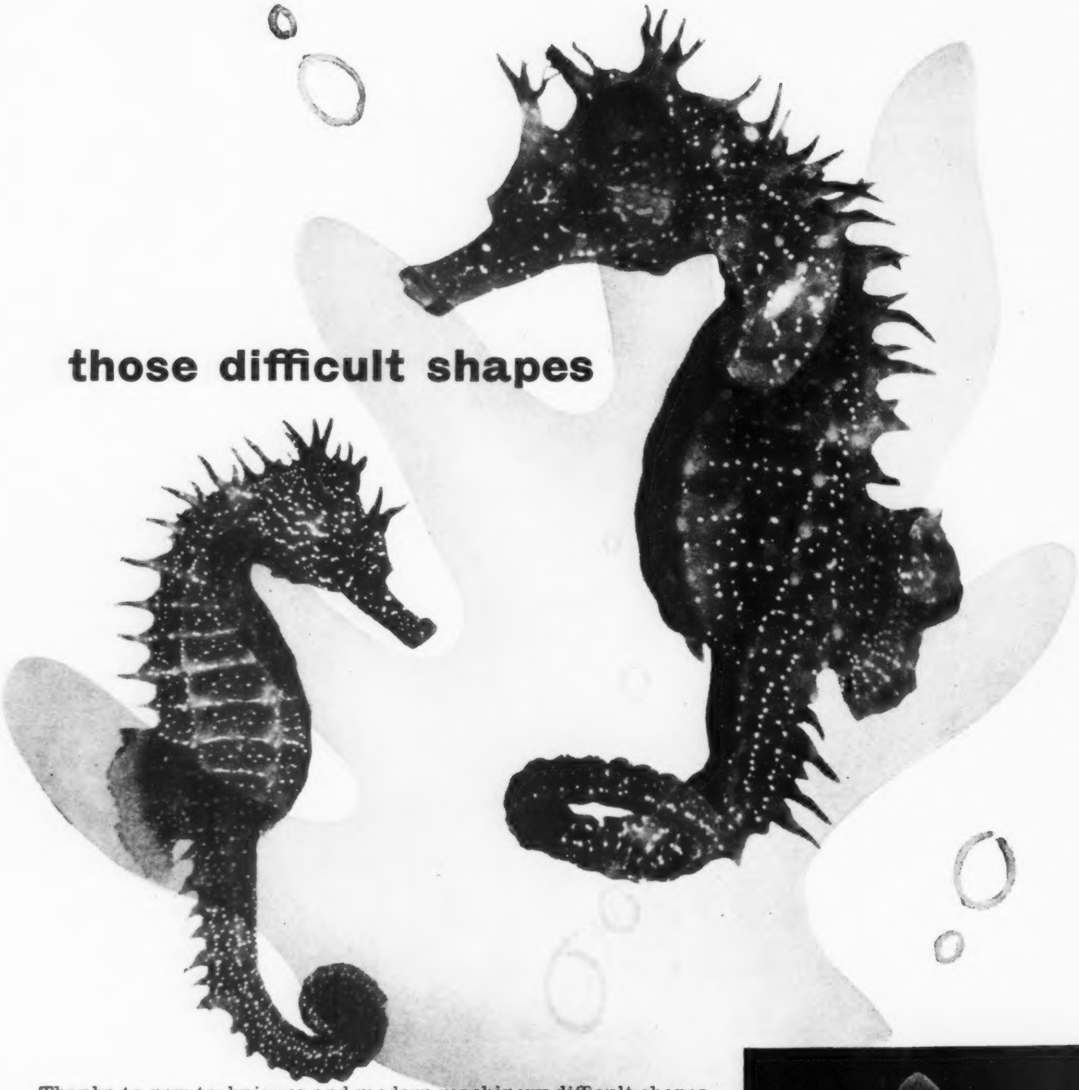

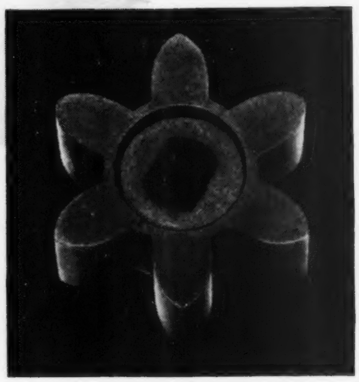

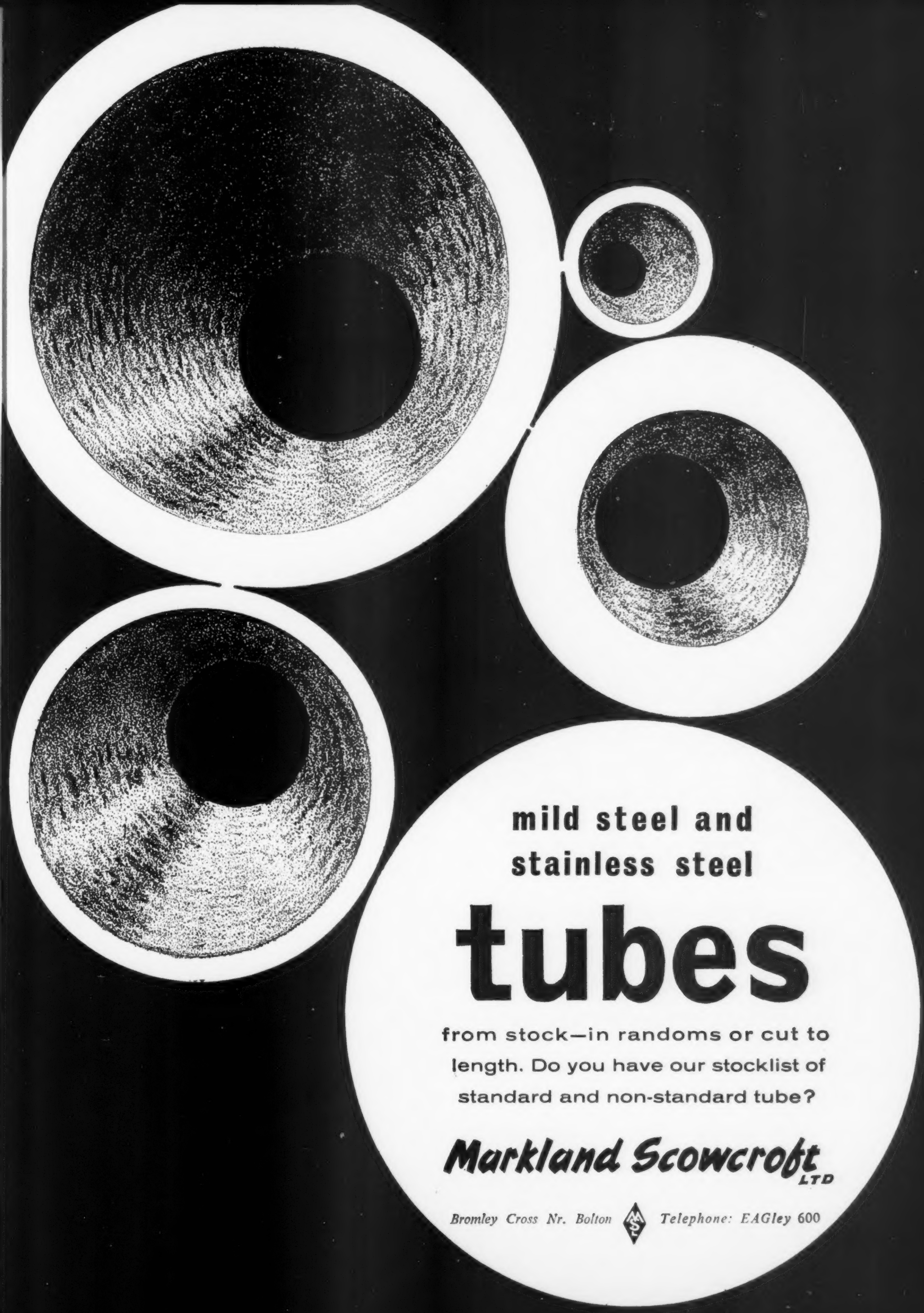
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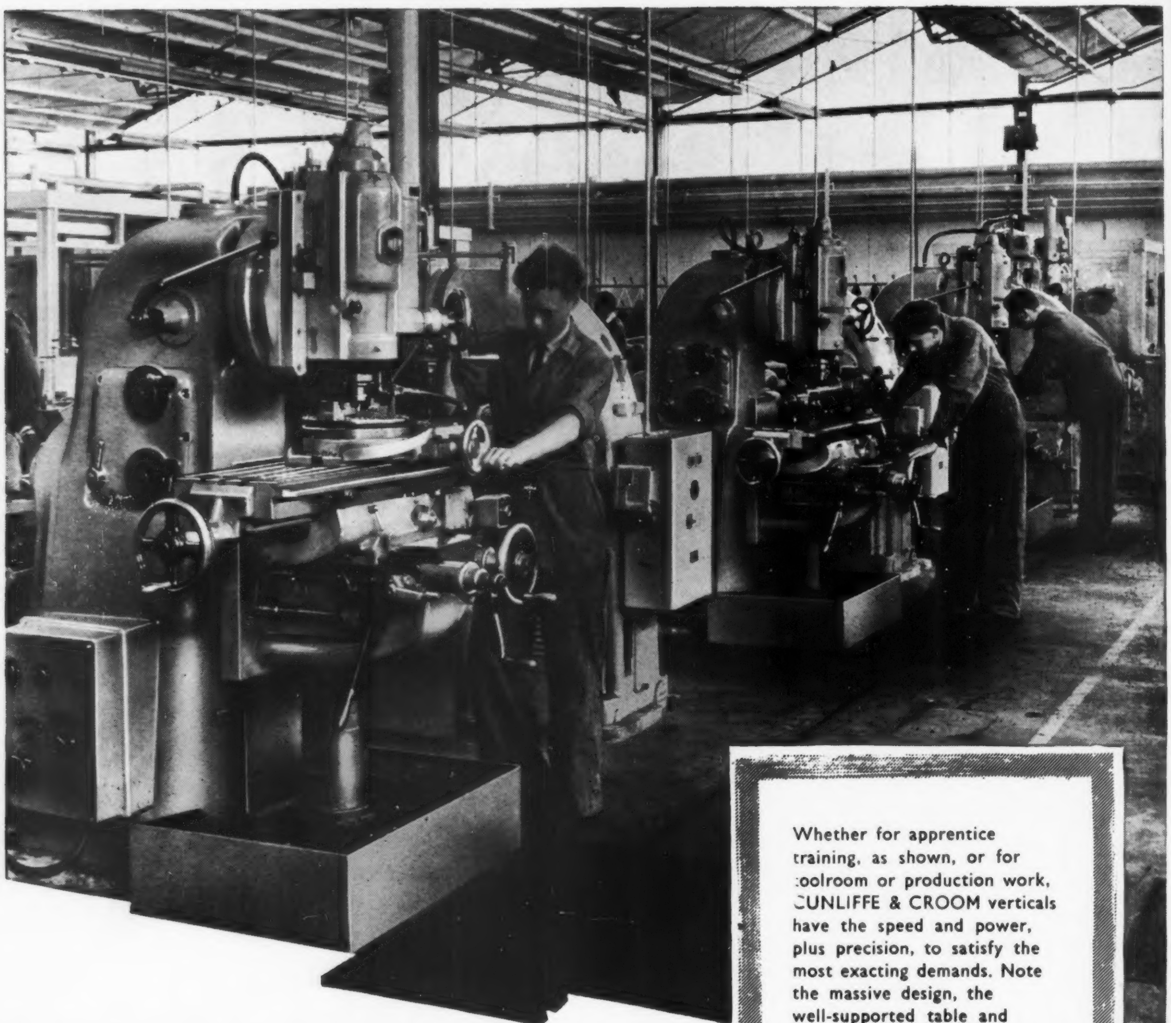

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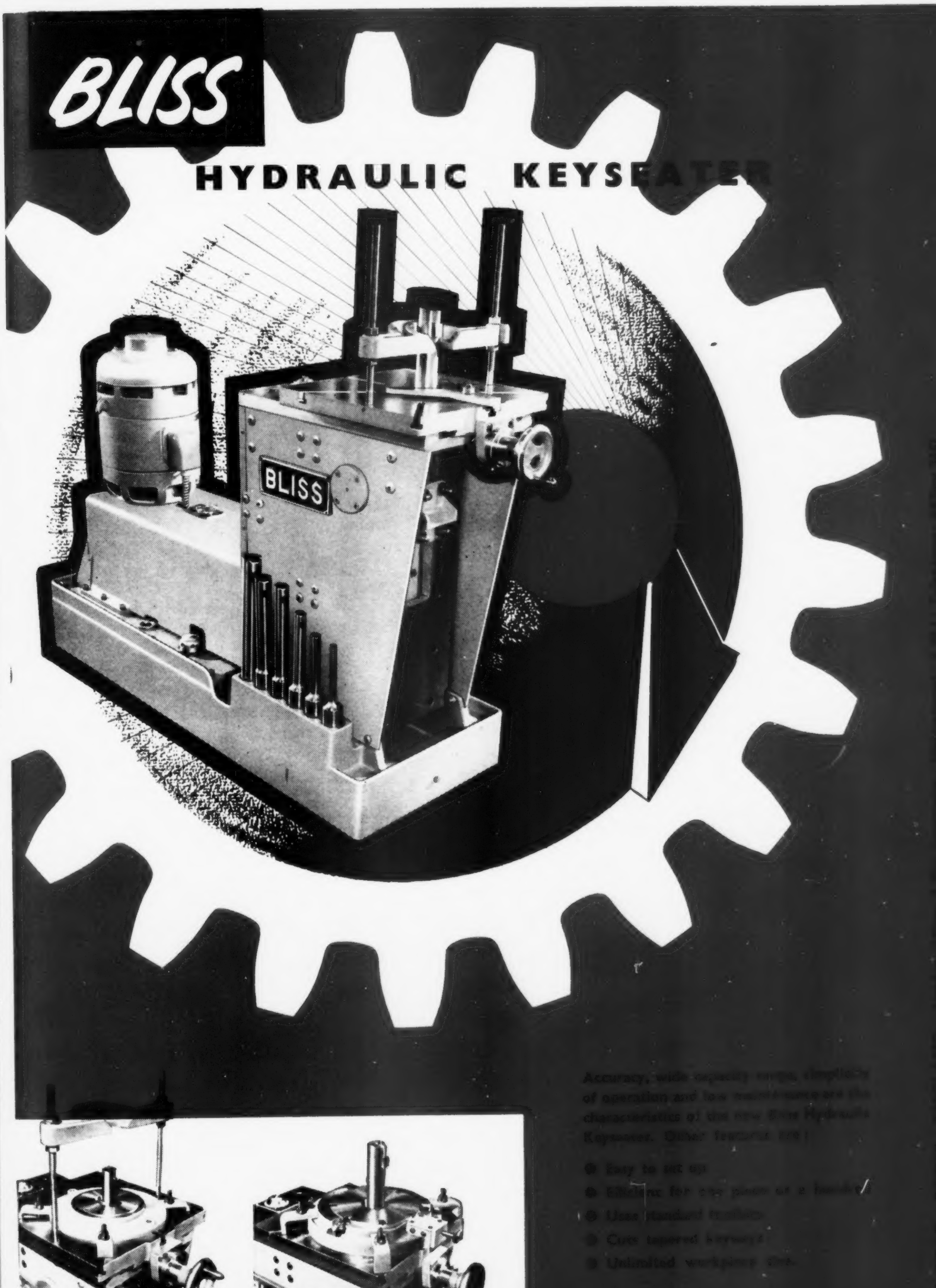
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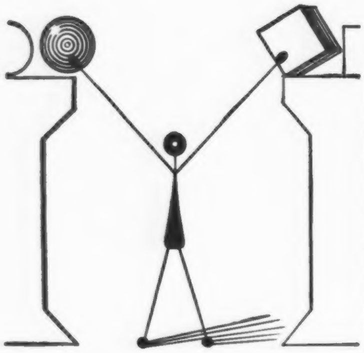
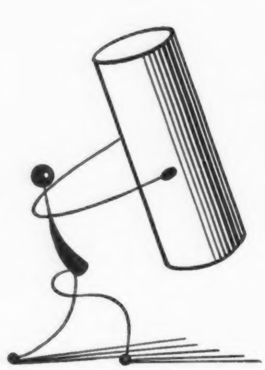
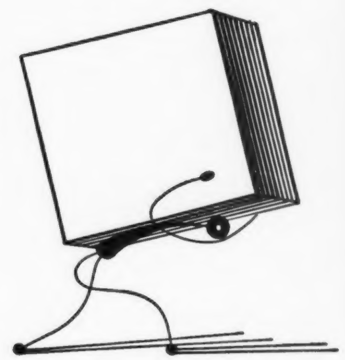


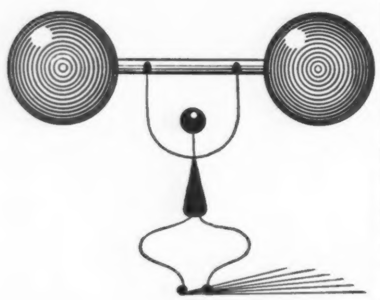
...reach...



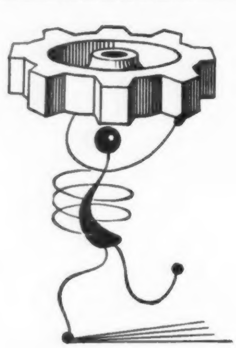
...grasp...



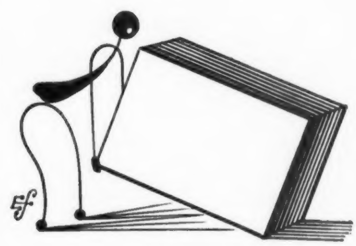
...carry...



...lift...



...turn...



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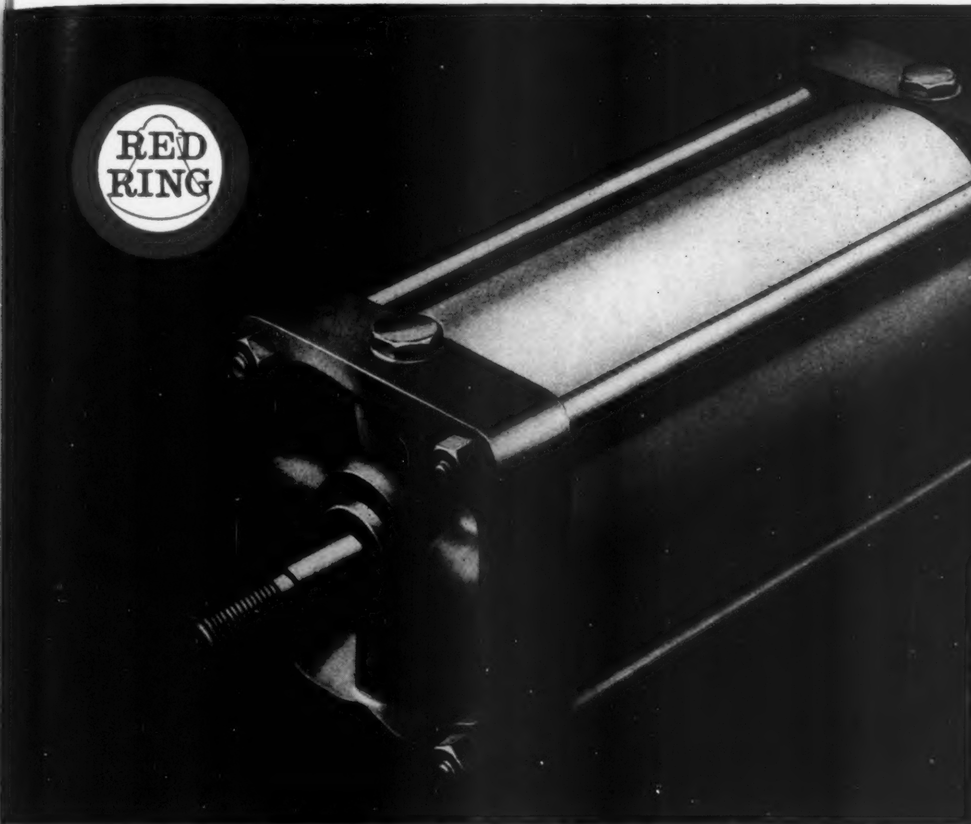

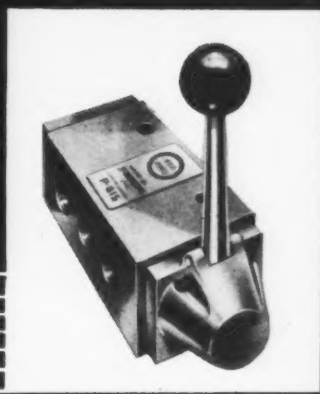

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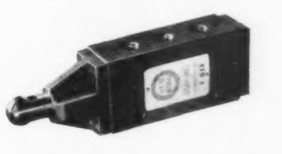

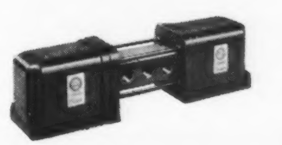

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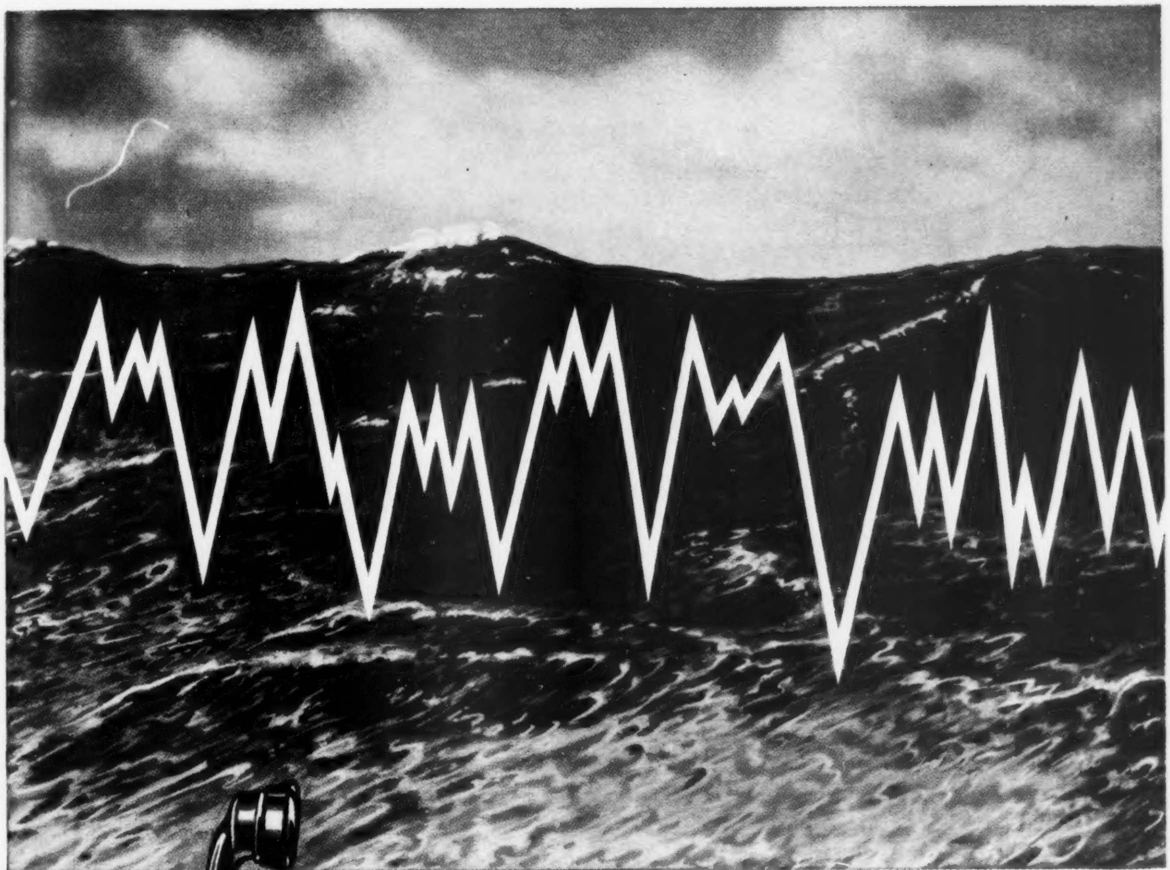


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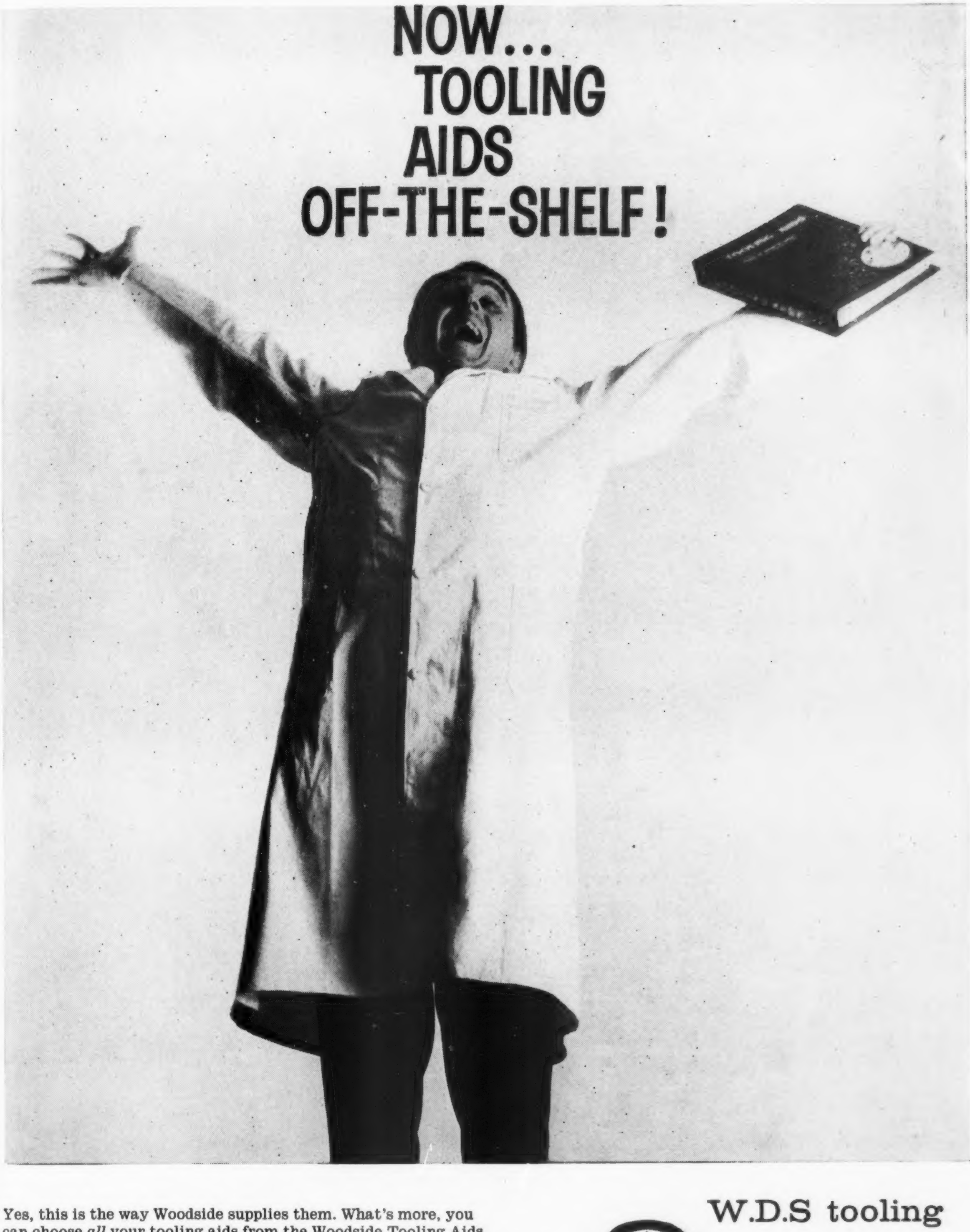
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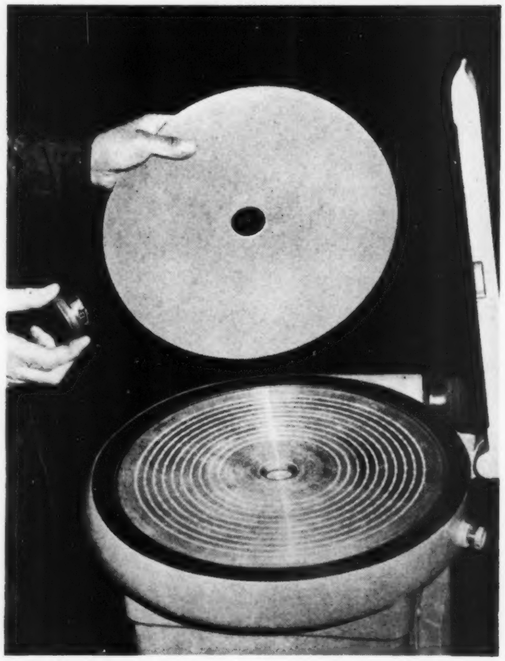


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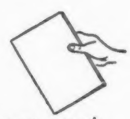

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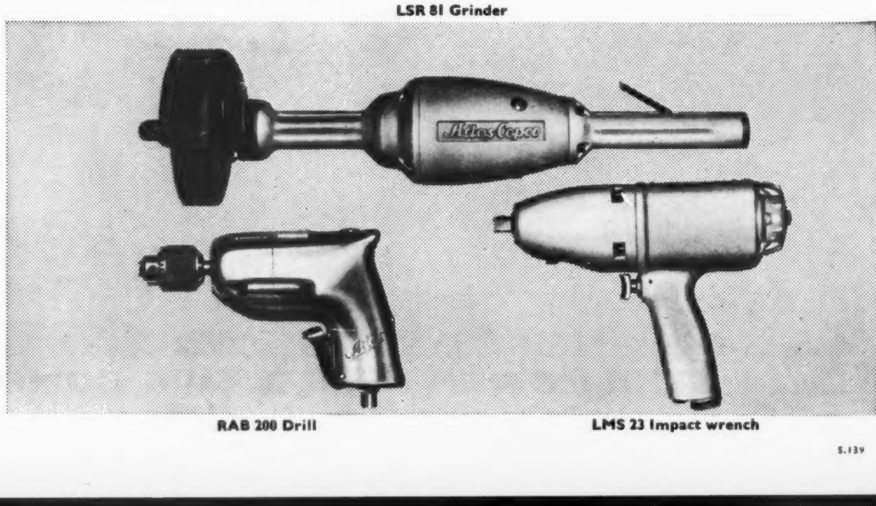

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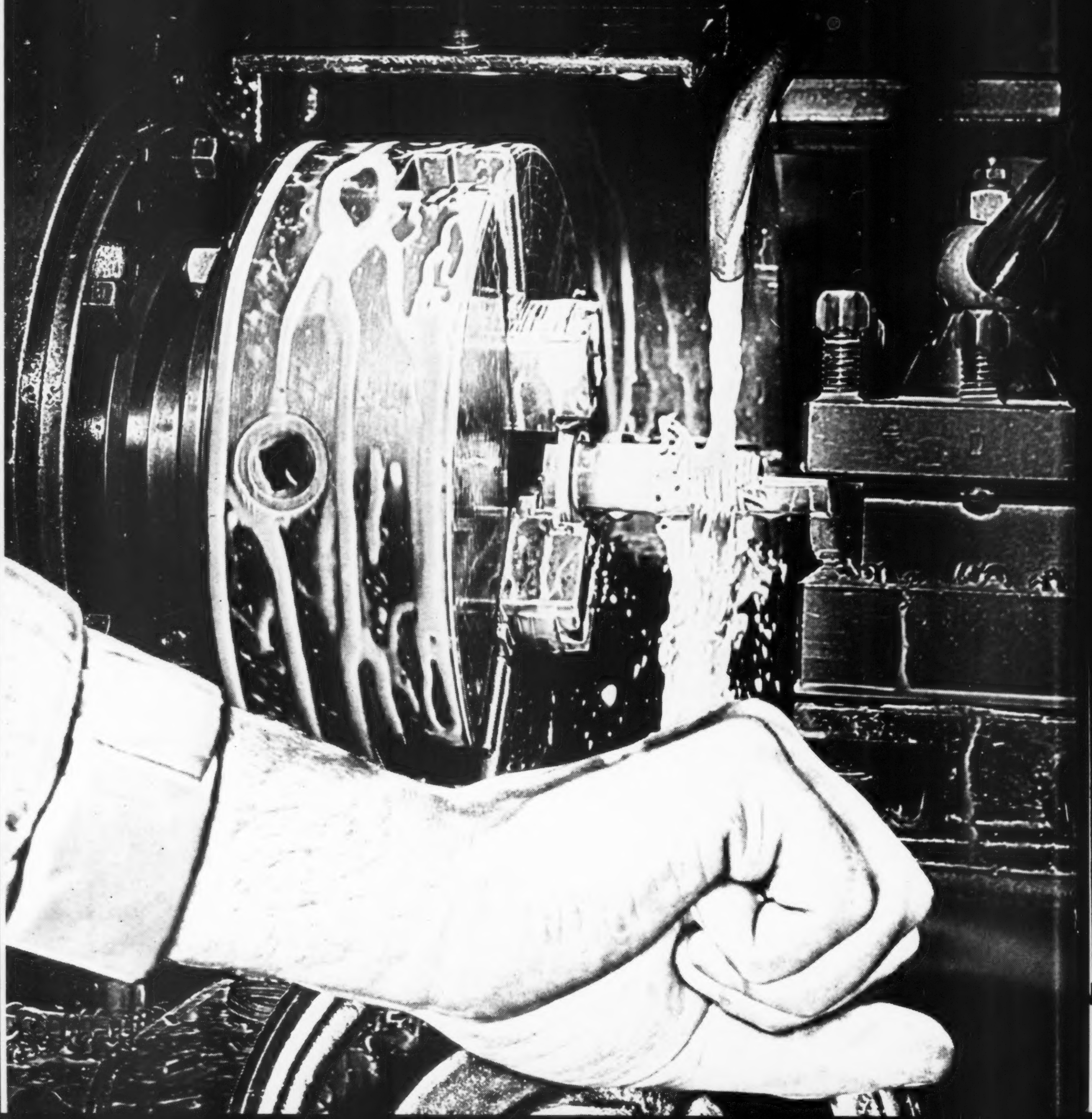

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Shell research chemists have been working on this problem, which has been causing some concern to Management. After considerable research, Shell Dromus Oils have been reformulated and these new cutting oils now produce bland emulsions, which considerably reduce the risk of skin trouble to operators.

The real difficulty was to find a new coupling agent to replace the phenolic compounds, and Shell finally used what their chemists know as a higher fatty alcohol complex. This solved one problem, but presented another. The new coupling agent was volatile at the high temperatures normally used in blending processes. Further research found a solution to this problem by designing and installing new plant.

The new Dromus Oils are every bit as efficient as before and cost no more. They put Management in the welcome position of being able to minimise working hazards at no extra cost. And machine men need no longer be so worried about skin troubles.

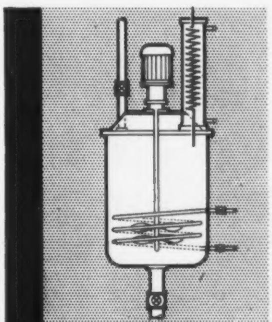
The moral of the story is that Shell research is supremely applicational. The centre at Thornton is always ready to work with even the most specialised sectors of industry to produce the right oil for the job. If you and your organisation have any major lubricating problems, it pays to get in touch with your local supplier of Shell Industrial Lubricants.

The Research Story

Shell chemists in the U.K., in Holland and in the U.S.A., prepared and examined hundreds of experimental soluble oils, and established that certain combinations of fatty alcohols could be used in place of phenolic compounds with no loss of efficiency. They set to work to discover the best combination and developed a higher fatty alcohol complex which fitted exactly. Then they realised that to blend this new coupling agent into soluble oils would require special plant and new blending techniques.

Exhaustive testing of blend stability, emulsion stability, anti-corrosion and machining properties led to selection of the most promising blends. A pilot plant was set up to produce batches of these for use in field trials.

This field testing and final development proceeded for two years whilst production plants were erected at points so chosen as to give the most economical and rapid delivery throughout the United Kingdom.



This is the blending kettle. The reflux condenser beside the stirrer motor prevents the loss of constituents volatile at the blending temperature.

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The Production Engineer

THE JOURNAL OF THE INSTITUTION OF PRODUCTION ENGINEERS

VOL. 39 No. 7 JULY, 1960

THE MANAGEMENT BURDEN

by HAROLD WILMOT, C.B.E.

Chairman, Beyer Peacock Group
Vice-President, British Institute of Management, 1959

This Paper was presented to the British Institute of Management, in London, on 30th October, 1959, as the Fifth Elbourne Memorial Lecture.

THIS is the fifth annual Elbourne Memorial Lecture. The purpose of these lectures is to remind management groups and others of the pioneer work of Edward Tregaskiss Elbourne, M.B.E. (1875-1935) and to add something to the body of management thought which was the inspiration and purpose of his living. In 1920 he founded the Institute of Industrial Administration, and was its first Honorary Secretary. It is clear that the present British Institute of Management, which incorporates the former Institute of Industrial Administration, owes much to the far-sighted practical idealism of this pioneer. He was a qualified engineer and a practical works accountant, a magnificent combination all too infrequent even in these days, and had considerable experience in the management of engineering factories. For 15 years he was an eminent consultant on problems of industrial organisation. Additionally he was the author of a number of publications, at least one of which is still a standard text-book. He was a man of vision coupled with tremendous enthusiasm and drive.

It is indeed an honour to receive an invitation to deliver the 1959 Elbourne Memorial Lecture.

The major implication of the title of this Paper is that positions of high authority in industry and commerce are inevitably associated with responsibilities and obligations which are onerous and burdensome.

Those who have not themselves held high office can know little of the isolation of the summit. Those who occupy such positions are usually heavily preoccupied. They speak or write but little of themselves and their personal problems. The fact that personal

authority is a matter of public interest; the fact that modern publicity methods are geared to accentuate such interest; the fact that but few men of high authority are skilled in the techniques of personal advertisement; the fact that the crudities of public personal analysis are distasteful to most of those who carry great responsibilities — these are some of the reasons why so little is known of the complete boss. There is also the fact that many such believe that it is inappropriate to equip oneself with a brass band when going duck shooting.

a distorted portrayal

Nevertheless, the lives of those in authority are of public interest and in the absence of an adequacy of clear, detailed and balanced evidence it is not to be wondered at that the films, stage plays and articles in popular publications, together with comment on radio and television, frequently portray the chief executive as a character so distorted as to be almost unrecognisable. There is undoubted glamour in the thought of great possessions and luxurious living. There is a fascination in contemplating the exercise of personal power. There is adventure in the heroics of appearing relaxed whilst in control of tremendous events. And it would seem that all this is fairly well understood, as indeed are the images of prestige, power, privilege and perquisites lurking in the background. They are equally exciting to contemplate.

The purpose of this Paper is not to probe and correct distortions in the portrait resulting from the exaggeration of conceptions of the sort described. In passing, however, it may not be out of place to remark that such distortions may, and in some cases do, add to those other burdens of management which are the subject of this discourse.

the burden of office

The burden of high office is no new conception. "Uneasy lies the head that wears a crown" is a thought expressed by Shakespeare. Machiavelli wrote of the problems of princes as they appeared to him in relation to 16th-century Italy. The public conscience in Britain at the time of the industrial revolution and its undoubted connection with an upsurge in nonconformity should also be noted with more than passing interest. A contemplation of the contemporary scene in industry and commerce would seem to indicate that while since the turn of the century much has been done to improve the working conditions of the worker in office, factory, field and mine (and quite rightly so) the lot of the executive has seldom been improved. In general, it may be said to have worsened both by comparison with the lot of the so-called worker and also in relation to many of its own former standards. Some ailments such as coronary thrombosis and duodenal ulcer are today frequently referred to as "occupational diseases of management". There can be little doubt that the strain of responsibility under conditions of ever-increasing business tempo is a major cause of the dramatic deterioration in executive health in the last half-century. Responsible and highly qualified medical researchers into this subject have stated in no uncertain terms that people in the higher income groups have a much greater than average death rate from "executive type" diseases.

It is not unreasonable to suggest that this unfortunate state of affairs stems from ascertainable causes, and that these causes are the burdens which fall on the shoulders of management and which are to a greater or lesser degree peculiar to management. Sooner or later there must be some attempt directed to the alleviation of malaise due to the management burden. Maintenance service is reasonably planned for expensive machinery. A similar service should be evolved for the most expensive and most burdened of all industrial equipment — the manager. This is both logical and reasonable. To understand the problem it is first necessary to study the burden. In fact there are many burdens or, if you prefer, many parts of the same composite burden. In my opinion the first of these burdens is

the necessity to think

There is no suggestion that management is alone in its obligation to think, or in its capacity for logical and constructive thought. Management thought has, however, a number of special characteristics. In the first place, lines of policy are usually laid down by Boards of Directors in general terms. This is not because directors in meeting do not desire to be specific. It is usually that they wish within the limits of policy to give management the widest possible freedom of operation. This creates maximum opportunity for initiative and tends to eliminate the menace of top level frustration. So management has to think out the instructions which will guide its own actions. The mental process is often one of posing questions and finding the answers thereto. Management must, therefore, find the right questions to ask. This is the way most planning starts.

To do the job properly — and most of what follows in management depends on this start — demands an allocation of time, the assembly of background information, an unbiased spirit of enquiry, a calm and judicial atmosphere, imagination and a "feel" of the situation. Nothing is quite so futile as time wasted in arriving at the right answers to the wrong questions. These periods of cloistered enquiry, evaluation, selection and plan-initiation occur at irregular intervals as the needs of business demand. Concurrently the business is operating in top gear. For a man of action to have to turn from the bustle of current activity in order to initiate and evaluate plans for the future demands more than attendance in another room, or conversations with another group of specialists. It demands a complete change in the mental character and outlook of the manager. There is no great strain in switching concentration from problem to problem in the same group of problems. Management is trained to do this and takes it in its stride. But to change from the active to the passive; from being the leader in battle to the chairman of a study group whose job it is to peer into the obscurities of the future; to produce on paper a resolution of forces and possibilities that may be crystallised or focussed into precise, workable and profitable plans,

demands qualities, both mental and moral, which as yet have not been sufficiently analysed or appreciated. It is clear, however, that the measure of this burden differs from place to place. For example, it is certain that size of enterprise has some effect. In the very large unit there is perforce a degree of functional division not suitable or practicable for the smaller enterprise. Analysis, synthesis, imagination, understanding and "feel" are, therefore, subject to a different mix and the burden is of a different sort as well as of a different degree. This is a fascinating field for enquiry and study. The interdependence of strategy, tactics, logistics and leadership clearly impose mental and moral management burdens which can only be carried with efficiency and comfort by the exceptional few who are of the highest calibre. Our purpose is surely to find ways of helping that inevitably larger number of good managers who perform adequately, but under great strain. If ways of relieving this strain can be found, then it may be reasonably assumed that a large number of good managers will perform with at least equal merit, but over a longer period and with greater comfort. It has been said that informed, logical, constructive, practical, visionary thought is the most difficult of all human tasks. It is just this burden which is as a matter of industrial routine laid on the shoulders of management.

The second management burden about which some thought is necessary is that management has perforce

to manage

This may sound trite. The active, dynamic ingredients of management, however, do not drop "as the gentle rain from heaven". In order to manage efficiently the manager must amongst other things have knowledge, experience, decision and an authority which is instantly recognisable though never mentioned or displayed. Some of these qualities are the result of thought and training. Some may be innate, to unfold gradually given the appropriate atmosphere or climate of opportunity. Some men have a degree of virility, thrust and capacity which will not be denied in spite of circumstance, discouragement or even active opposition.

In order to direct active operations the manager must have authority. All proper industrial organisation gives weight to both the area and the degree of authority at all levels and to proper relationships between these degrees and areas of authority. Management authority is not just the opportunity to push other people around. It is not to be evidenced only by the number of square feet of carpet or the number or kind of chairs in the manager's office. It does not consist of having a pretty young woman as secretary, nor of having a box of cigars on the desk and a bottle of liquor in the cupboard.

Managerial authority cannot exist or persist in the absence of discipline, and discipline in the management sense has complicated and burdensome implications. No manager is fit to discipline others till he has learned to discipline himself. In an organisation it is always true to say that the junior acts so as to ascertain how far he can "put it over" his senior! What is the permitted degree of laxity in control? What is the minimum of merit or the maximum of mediocrity permissible without open censure? Any manager knows this to be true in relation to any new boss. What is now suggested is far more subtle and insidious. It is that every thinking manager is subject to self-questioning along similar lines. The higher the rank, the greater the need for comprehensive self-discipline.

There is an undoubted tendency for the lower grade to copy the upper grade. It is equally undoubted that such imitation tends to start with faults or vices rather than austerities or virtues. The mere fact of this human foible should be sufficient to guide the thoughts and conduct of responsible managers. But it is not easy. It is in truth part of management burden. The thought of having to discipline others, which in some measure involves judging them, only adds to the burden. In passing, I would like to mention two items of indiscipline which add seriously to the management burden. First, the indiscipline of shareholders who refuse to accept the responsibilities of ownership in that the overwhelming number of them refuse to take part in general meetings either by their presence or by proxy. Legal provisions might be made to modify the rights of owners who persist in refusing to use their votes. Management is frequently disgusted and occasionally frustrated by owner indiscipline, and some form of relief should be provided.

Secondly, the indiscipline of the unofficial wild-cat striker. His membership of a union infers a voluntary submission to the rules and regulations of it, just as the grant of nationality infers submission to the laws of the country concerned. Provisions might be made to exclude from membership those who incite to unofficial stoppage. Other penalties could be made to apply to those who follow such irresponsible and undisciplined leadership. It is interesting to note that some unions are now thinking seriously about this. The freedoms of Western democracy do not mean the licence of the jungle — the right to create chaos by the display of individual selfishness at the expense of the community—however strong or influential—to defy the law and not to suffer the appropriate penalty. We must, however, get our thinking and our laws right first. The same applies in the industrial scene with regard to management and the body of employed persons who are properly subjected to industrial discipline.

unnecessary disputes

I have been personally involved in the various levels of industrial management for nearly 40 years. My own conclusion about industrial disputes is that more than half of these disputes are completely irrational and unnecessary. I have a great regard for the essential integrity of both the manager and also of the industrial craftsman. What often irritates the latter to the point of exasperation is when there is delay (and inferred indifference) in dealing with complaints. This is a matter for management discipline. Individual complaints made by bodies not larger than a single department in a factory should

proceed through the various appropriate stages, and if not settled on the way up should come to the attention of the chief executive within 24 hours of the first notification.

Authority for settlement on the management side must be delegated as far down the scale as is possible. Authority connotes service: "He that is greatest among you , let him be as the younger; and he that is chief, as he that doth serve". The benefit of the doubt should always be conceded by management in border-line cases and an apology for error freely given where this has been ascertained. The complaint of injustice or unnecessary hardship of one single person, if unanswered or unresolved for as little as one month, can fester and grow till a complete factory is roused to resentment and anger. The open evidence of speedy rough justice which can be seen to be in action without prejudice, acidity or rancour makes for good management-worker relations and reinforces the authority of management. Discontent is like a forest fire. It must be stamped out at top speed. Time is the enemy. Delay or indecision is fatal.

This emphasis on speed, this necessity for rapid appraisal, quick decision and immediate settlement with rough justice maybe, but without any need for appeasement or weakness, imposes a considerable mental and moral burden on management. To be 80% just with speed is far more meritorious than to be 95% right too late — and it is more difficult and burdensome.

The third management burden to which I would like to draw your attention is the obligation laid on management

to inspire

To inspire others is of the essence of true leadership. The process is partly calculated and partly unpremeditated. It demands a superiority of knowledge coupled with a readiness to listen to the opinions of others. The superiority of knowledge must be apparent, and the fact of this difference is more important than its degree or measure. Leadership of the right sort presupposes great intensity of personal conviction. Indeed, the concentration of personal belief must be of a nature which excludes the possibility of reason or validity in other points of view. There is no room at the top for the manager who swithers, who can see two or more sides to each proposition, and who cannot acquire a genuine and intense conviction of the essential rightness of one to the exclusion of all others. To enthuse others, the manager himself must burn with an enthusiasm which will not be denied. Such enthusiasm is contagious. It is part of the management problem. In these days there would appear to be fewer propositions which can be categorised as black or white. There are nowadays so many degrees of grey in between. Management has to see the crudities of black and white without any intervening neutralisation. For this reason it is obvious that dynamic management of the sort being discussed demands the vigour and confidence of youth. Either the older men in management must retain or recapture these capacities, or they must step aside in favour of younger men.

Intensity of conviction must be accompanied by a serene self-confidence; intense convictions which tear the heart out of a man, which lead to nervous tension and irritability, indicate the unsuitability of the individual to manage. The true manager is calm, quiet, serene. He is tranquil without the aid of tranquillisers. Such a one has been described as "a no-ulcer man doing a five-ulcer job". Serenity can only be acquired if the manager is relaxed whilst in control of tremendous forces; whilst directing them efficiently along prearranged paths. Such serenity is evidence of managerial greatness. Such a leader does not lack devoted followers. He has a flair for initiative; the capacity to see, judge and take the calculated risk. His decisions are swift and clear. He must usually be right!

the communication structure

But all these prior essentials cannot produce the fullest result unless in addition the manager has a complete mastery of the art of communication. The communication structure is a matter for precise planning and much has been written of that exercise. A great deal of ink has also been used in describing the operation of the communication structure. It is, therefore, only necessary to emphasise three simple points and then to state something which I believe to be new. Communications should be in unambiguous language, should be precise and concise, and should be addressed clearly to the intended recipient who should acknowledge or reply. These points concern written communications. I believe that the art of communication is somewhat wider than this. The manager has to arrange that his communications are received, understood and acknowledged. But in addition he should so arrange that his communications are appreciated. This may perhaps best be achieved by what I would call the leap-frog system. Under this system the manager would take regular pains to explain his approach to various problems not only officially to his immediate subordinate managers, but also unofficially to the rank one step further down the line. He would also see that his organisation followed this plan right down the line of command. The benefits of such a scheme are many. Appreciation that orders are not merely the whim of the immediate boss adds greatly to the coherence of the management team, and prepares the way for that degree of delegation which is so desirable, but which may be unnecessarily dangerous in the absence of adequate coherence.

Another type of benefit is concerned with promotion. The leap-frogging downwards breeds two-way respect which assists in making promotion the swift and relaxed exercise it ought to be. There are many more aspects of leadership which repay study. For the purpose of demonstrating the management burden I need to mention but one more — a sublimated tenacity of purpose. The Frenchman who said: *"C'est le premier pas qui coute"* had only part of the story — only a fraction of the truth. It is at least equally true to say that

" it is the last battle which if won wins the war ". Or equally " it is the last mile which reaches the objective ". Management must not grow weary when the going is difficult, must not falter when the objective seems to be obscured, must not hesitate when plans miscarry, must not despair when colleagues and helpers give up, must never doubt eventual success and must under all conditions exude a cheerful and purposeful confidence. To management of that order nothing is impossible. The challenge of adverse conditions provides the opportunity for management to reach heights of achievement which are the central justification of authority. Such operations are tremendously burdensome. The effort and the success are seldom properly recognised and are usually all too quickly forgotten.

This list of managerial qualities necessary before a man may reasonably expect to inspire others is not complete. But I have said sufficient to warrant the statement that the task of inspiration in the sense disclosed is one which imposes grave and heavy burdens on those who seriously try to fulfil their obligations as managers.

The fourth burden which persistently recurs and with which management must of necessity deal, is the judgment of others in the light of which the manager has a duty

to reward or to punish

I can think of no task more onerous and burdensome than that of judging the conduct, capacity and performance of one's fellow creatures. This is one of the constant burdens of management. Most men of experience and mature mind are more than conscious of the weight of the Biblical injunction : " Judge not that ye be not judged ". There is, of course, much disregard of this in the trivialities of common experience. But for some unenviable mortals the very nature of their office requires of them the judgment of the conduct or performance of others. Only those who have been or who still are in this situation know with what reluctance this part of their duty is undertaken. In order to fulfil these duties properly a manager must be mature, knowledgeable, logical, calm and impersonal. He must have the capacity to differentiate between the important and the trivial. He will on occasion have to visualise the relationships which lie between cause and effect. He must from time to time assess personality whilst evaluating performance. His aversion for injustice must amount to hatred. He must have a humble passion for what is fair and right and true. He must exercise diligence, care and patience in getting at the facts. Indeed, he must be a paragon of knowledge, wisdom and integrity. It is part of the job — part of the management burden. Let the manager get on with it.

But this is not all. Having made his evaluation, having arrived at some decision as to the degree of merit or the extent of the imperfection, he must now make a decision as to the nature and degree of reward or punishment. It is not for me to suggest by what means he arrives at the right answers. That may largely be special to the place or time or circumstance. There may be an existing body of knowledge or precedent or calculation all ready to hand. It may not be out of place, however, to remind you of some of the rules the manager must have in mind at these times.

First, his judgment must be just and it must be clear to all interested that this is so. Next, any reward must be tinged with just the right amount of generosity. The reward should always be a little more that what would be fair. The reward must be made willingly. There must never be any suspicion that there is any reluctance on the part of the manager. The reward must be made as an act of justice, not charity. Above all, the reward must be made quickly. Only thus will the connection between merit and result be most obvious. Only thus will maximum content reside in the recipient. For over 2,000 years there has been much truth in the adage *Bis dat qui cito dat* — He gives twice who gives soon.

If the problems of reward are burdensome, how much greater must be the burden of the problem of punishment or penalty? I would like to say something on the general subject of punishment. In the first place, there must be clear evidence of the unquestionable integrity of the manager making the decision. The penalty should follow swiftly after the misdeed or imperfection. There must be an obvious connection or relationship between the two, so that the punishment is also a warning to others. The person punished should always be given the benefit of any reasonable doubt. The last thing I would like to do is to pontificate about punishment. But I would nevertheless remind managers that the quality of mercy is not something the manager should regard as something outside, beyond and not really appropriate to the processes of managerial judgment. Well might they remember those famous lines put into the mouth of Portia by Shakespeare when of mercy she says :

> " 'Tis mightiest in the mightiest; it becomes
> the thronèd monarch better than his crown."

How true this is today in industry and commerce! And as this is so, it must follow that all punishments must be given with obviously sincere reluctance. By this I don't infer that the formula : " this is going to hurt me far more than it will hurt you ", so familiar in childhood's experience, should ever be used. The manager who is sincere will, however, always bear some of the burden of the punishment he must inflict. This is obvious to those who realise that most managers are sensitive, imaginative and sympathetic humans behind the facade of their authority and power. Somehow punishments always seem more personal than rewards. Somehow standing in the shadows behind the person punished there is always, in the imagination of the manager, the image of parent or wife or child and the multiplication of sorrow and suffering which in itself is one of the mysteries of life and a very real burden to management. It is easy to say that the manager should always punish in an impersonal way. Where it can be achieved, there is great relief. The problem is to find a way to make penalties less personal. I don't

know the answer. I do know that the problem adds to the total of the management burden.

There are many more aspects of the management burden. I am only going to mention one of them—the supreme necessity to look to the future and to plan so that at the appropriate time management will be in a position

to replace

It is a truism which cannot be emphasised too frequently that "no company is better than its management". A mediocre management in a lush business may appear to perform better than a good management in a difficult or depressed undertaking. Beware of the dangers of such comparison. Useful comparisons may only be made between examples which are or can be made to be comparable. I am not excluding the benefits of properly devised inter-firm comparisons when I say that normally management comparisons should be between performance and plan.

It is clear that managements must be renewed. It is equally clear that business is becoming more and more complex. It seems reasonable to suggest that for management in the future to perform only as well as present management, the future management must be of higher or superior quality. If management is to put up a performance of increasing excellence, then the quality of management must be improved by substantial margins. This will not just happen. Management cannot rely on occasional advertisements in the national and technical press to produce the better management material in adequate quantity. A glance at current advertising will indicate how desperate the situation is. It will also show how much money must be spent in the ultimately unproductive exercise of tempting good men to be drawn into the employment merry-go-round. The problem arises from the fact that we do not have sufficient high grade entrants.

This is a management burden. It has been said that to acquire a good manager you must first catch and train his grandfather. There is some significant hidden truth in that saying. The problem of getting a sufficient number of high-grade entrants to the fields of management must surely lead back to the schools and universities. For a large number the choice of profession is decided in those early stages. The decision usually comes from a sense of vocation, a knowledge of the public social esteem for a profession, heredity or the influence of family and friends, the possible monetary rewards and the facilities readily available for training. On this basis, or indeed on any other, management does not get anything like a fair share of the pick of the universities. How to rectify this is a matter of the greatest importance and also of the greatest difficulty. It is a management burden which, however onerous, demands more conscious and more constructive attention. The problem is a sort of "which came first, the egg or the chicken?" one.

Youth is the admitted time for idealism. Mercenary or sordid objectives have but little appeal to the type of student management wishes to attract. Educational authorities, career advisors and indeed the educated and informed public must, therefore, be convinced of the high standard of management ethics. They must believe that the completely acceptable moral basis of management is a proposition beyond doubt. Until educational opinion and, to a lesser degree, public opinion has moved to convictions of the kind described, there seems little hope of management securing the type and quality of recruits it so desperately needs. Management must, therefore, be represented to such as a wholly beneficent service, a service calling for the highest standards of character and morality; a service needing the best brains and the most vivid of balanced imaginations; a service demanding dedication, self-discipline and often self-sacrifice; a service offering unrivalled opportunities for self-expression and personal fulfilment; a service which in time breeds an aristocracy of character and personality. In this matter the management burden is first of all to ensure that the picture of management thus drawn is indeed a true one, and secondly to plan and procure that this picture is adequately publicised.

But this is not all. Universities, Colleges and other educational foundations must be persuaded to introduce the right kind of courses of study. Professors, lecturers and teachers must be carefully chosen and properly prepared for their duties. Managers must be willing to allocate a portion of their own time to the task of talking to students while they are in theoretical training, and for receiving them in small parties at their places of business so that management processes which are being taught may be exhibited and displayed in action. Furthermore, management when successful in attracting such recruits must display care, patience and wisdom in absorbing them into the management team or structure. These colts are thoroughbreds (if I may be pardoned for the expression) and must be so regarded. This will call for the exercise of great tact and firmness from the top managers to ensure that down the scale of management these examples of a new, and we hope better, breed of recruit are acceptable and are accepted. This task is also part of the management burden. The atmosphere must be prepared before the arrival of these recruits. Throughout the organisation there must be a conviction of the potential value of the top grade entrant. Equally there must be an open readiness to welcome rather than to ignore, to trust rather than to suspect, to encourage rather than to provoke or tease, to assist rather than to impede.

I have tried to remind you of some of the important aspects of the Management Burden :

- To Think and Plan
- To Manage
- To Inspire
- To Reward or Punish and
- To Replace or Renew.

I have tried to indicate why I think that the burdens thus imposed are onerous and severe. I have not mentioned the problems of the initiation, continuation and application in practice of the work of

the researcher — pioneer — prototyper — experimenter. Nor have I mentioned the load imposed on management by the continual struggle between the back-room boys and the production engineer who needs maximum runs of standardised design. And there are, of course, a number of other aspects of the management burden which cannot here be examined.

At the beginning of this lecture, I stated that as a result of the management burden in a period of ever-accelerating activity, top executives were more and more the victims of a number of lethal disabilities.

It is, of course, entirely proper and commendable that science and medical science in particular should strive to find ways of alleviating this distress and suffering. This is not an exercise in compassion. Burdens too heavy for comfort in the carrying must lead to fatigue, which in turn must result in a serious loss of managerial efficiency. At this point, if not earlier, the whole organisation feels some of the effects and tends to lose some of the rhythmic tempo which is the essence and evidence of a smooth running highly efficient management team. The business as a whole loses vision, loses stimulus, loses vigour, loses direction and loses profit. It drifts into dangerous areas of jeopardy. To avoid this is not being sentimental. It is in the highest sense enlightened self-interest. But the devoted work of doctors, surgeons and researchers of various types is not enough. Their work is at the moment largely remedial in nature. How much better it is to eliminate the need for at least a part of such remedial measures by removing the malaise which is their *raison d'etre*.

easing the burden

I would like to suggest that Government itself should be conscious of the supreme national value of good management. Logically the duty of Government should be to relieve management of unnecessary, illogical and quite unfair financial burdens. Managers are, I suppose, normally in the £1,500 - £10,000 per annum income group. If my statistics are correct, supertax in 1913 was 6d. in the £1 maximum rate, with the first £3,000 of income exempt and with a standard rate of tax at 1s. 2d. in the £1. In 1958, the level of exemption was £2,000 per annum (where it had been since 1920) with a top rate of surtax 8s. 6d. in the £1 above £10,000, rising to 10s. 0d. in the £1 over £15,000 and with a standard rate of 8s. 6d. in the £1 income tax. Incidentally, if the £1 sterling was worth 20s. 0d. purchasing power in 1913 it was only worth 24% of that (less than 5s. 0d.) in 1958. What a burden! What a load! How unfair! Government should act immediately.

And management may itself play an important part in making provision for improving the lot of the manager — for lightening his burden and/or seeing that he is better able to cope with it. To reduce the burden must imply giving the manager less to carry. In this sense, there should be the most vigorous drive to take from the manager all but the most important of his responsibilities, by eliminating the trivial and by intensified delegation. The need for this is urgent in most businesses. It is, however, particular to the business and is, therefore, no concern of mine in this Paper.

essential qualities

To see that the manager is better able to cope with his burden demands a number of prerequisites. For example, the appointment of the manager should depend on certain qualities and qualifications. To bear a heavy load comfortably a man must start with good health. His mind should also be healthy and his philosophical, community, social and domestic relations should be of a nature which will produce a serenity easy to detect. He should have a keen sense of humour and the capacity to laugh at himself as well as at the other fellow. He must retain a balanced sense of values whilst keeping " the common touch ". Assuming that there has been conscious care to recruit the right type of person to the ranks of management, it is necessary to make such provisions as will tend to keep him healthy and relaxed. One such provision is for the non-executive members of the Board of Directors to refrain from time-wasting and often unnecessary questions or enquiry, or even semi-social visits. Another is to encourage as far as practicable open-air pastimes or hobbies of a sort which take the mind away from business for a period. Many managers are too intense for too long. It would also be a wonderful thing if the brief case could be abolished and managers discouraged from taking papers home in the evening and at week-ends. For the top executive the actual number of hours " at the office " might be restricted. His problems are always with him but even a change of atmosphere is a help in relieving tensions.

These are things we can all do something about. I am satisfied that a collective attempt would make a formidable contribution towards the solution of the many problems of the management burden. The idea of a top management club has never really taken the imagination of the right men. Some infrequent dinner parties organised by the British Institute of Management and to which only top executives would be invited might be one way of relieving the man at the summit of some of his isolation. But the numbers at any such party should be severely restricted so as to achieve an atmosphere of intimacy and informality. The arrangements would naturally be of a suitable order. There should be no organised subject for discussion. The British Institute of Management might launch the boat, so to speak, and leave the top executives to steer it wherever their whim might suggest.

In Scotland there is a saying " facts are chiels that winna ding ", which means that it is hopeless to argue with facts; you cannot bend them to your will. The same can perhaps be said of top executives. One has to suggest ways by which they might perhaps help each other; even sustain each other. But in the end it must be left for them to evaluate and accept or reject — which, after all, is only what might be expected.

In the short time permitted to an Elbourne Lecturer it is not possible to deal with such a subject

as " The Management Burden " in any but the most limited and sketchy manner. I can but hope that incomplete and unsatisfactory as it undoubtedly is, my attempt to draw your attention to the burdensome nature of management may be of some slight service to management thought and to those objectives for which Elbourne strove so persistently in the early days.

Any analysis of this burden inevitably calls for some examination of the manager himself. I make no apology for having said so much of the many qualities and qualifications the manager must possess if he is to achieve success in his many burdensome tasks. Of necessity the man who " carries the can " stands at the summit and alone. Otto Prince von Bismarck, in his memoirs, wrote :

> " Official decisions do not gain in honesty or moderation by being arrived at collectively; for apart from the fact that, in the case of voting by majority, arithmetic and chance take the place of logical reasoning, that feeling of personal responsibility, in which lies the essential guarantee for the conscientiousness of the decision, is lost directly it comes about by means of anonymous majorities."

The man who stands at the summit must stand there alone. He has the authority. He has the responsibility. He must initiate or approve the plan and see to its execution. He must have knowledge, wisdom, judgment. He must lead, drive, inspire. He must judge and reward or punish. Finally he must from time to time retire others and must at the appropriate season retire himself. And this latter must be arranged so that change and transfer seem natural by their very smoothness. He is not usually an owner. Popular conception, however, seldom concedes him the appellation " worker ". He is always overburdened. He is frequently unappreciated. If things go wrong he is invariably blamed. In success he is usually overlooked. He is generally underpaid and frequently disparaged. His motives are often regarded as dubious, so his repute and prestige are low.

But he remains the focal point of all effort. His decisions, more than those of any other, lead to success or failure. In fact he is a paragon, a friendly autocrat, an earth-bound archangel — the personification of the proposition that " Man was created in the image of God; little lower than the angels; the Lord of Creation ".

Yes, he is all that. Nevertheless he is sorely tried and overburdened. He is all too well aware of his frailties and imperfections. This is the man who deserves the help of science and of management thought. He is in increasing need of relief without interference — of understanding without demonstration — of comfort without fuss — of loyalty without intrusion — and indeed of aid without strings.

It is my earnest hope that such amelioration as I have mentioned may quickly be achieved. In this way the Management Burden would be significantly reduced.

BRITISH CONFERENCE ON AUTOMATION AND COMPUTATION

"AUTOMATION - MEN and MONEY"

to be held from 4th - 7th July, 1961

This Conference will be of interest to all in the general management and specialist fields in industry and commerce. It is to be sponsored by those bodies which form the membership of Group " C ", a sub-committee of B.C.A.C. :

The British Institute of Management	Institution of Production Engineers
Department of Scientific & Industrial Research	The British Productivity Council
Institute of Cost and Works Accountants	The Trades Union Congress
	Institute of Personnel Management
	Tavistock Institute of Human Relations

The programme will be of three days' duration, commencing with a plenary session and reception in the evening of the opening day, and concluding with a second plenary session in the morning of the final day. It is proposed to hold sectional meetings in the morning of each day, and that these will take the form of four series of meetings running in parallel.

The final plenary session will consist of an address by Sir Walter Puckey, Past President of the Institution of Production Engineers.

Further details of the programme will be announced as they become available.

AN INTRODUCTION TO PRODUCTION ENGINEERING ADMINISTRATION

A Thesis by R. G. MOCKLER, A.M.I.Prod.E.

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INTEGRITY and mature judgment are the basic foundations necessary for the privilege of being an administrator.

Integrity can be defined as honesty and loyalty as an inbred characteristic. Mature judgment is a blend of knowledge and experience founded upon burned fingers, disappointments, and fears as well as success.

There are no short cuts to good administration; basic rules effectively applied with intelligent judgment make for the best administrator.

This Thesis has been prepared with more concern for the fundamentals of the subject than practical application, for two reasons. Firstly, there are already many excellent books written by leading administrative authorities, with whom it is not intended to compete, on the practical applications of production engineering administration. Secondly, it is anticipated that any person who is interested in this subject will already be familiar with the principal aspects of planning, estimating and ratefixing.

No credit is claimed for originality of facts on this subject. After much research into existing publications, an attempt has been made to compile what are thought to be most important factors toward attaining an orderly, conscious, and human approach to production engineering administration.

requirements and preparation for an administrative position

Over the years there have been many arguments as to the merits of technically-trained men versus management-trained men for appointment to administrative posts. Both factions have valid and reasonable arguments; but in the production engineering field both technical and managerial competence are equally desirable. To achieve this balance successfully, the future administrator must pass through the technical administrative levels to the higher levels of management in an orderly manner.

When considering requirements for production engineering appointments within the lower echelon, emphasis must be placed on both practical and technical competence. As progress is made toward higher appointments skill in practical and technical fields will lose its keen edge, but a new skill, administrative competence, is acquired.

It is part of management's responsibility to stimulate every employee to make the best use of his ability, and to provide recognition of his attainments. In many plants there are craftsmen with maturity, character, experience and knowledge who, if given the opportunity and the administrative training, would make first-class administrators. Selection of the man of the right calibre within the plant is not a difficult operation. A man may hide, or misrepresent himself to you, but he cannot hide his perseverance, his imagination, or his ability to apply knowledge and common sense effectively to a situation; all are there, in his work.

Administration requires the exercise of many functions with which a non-administrative employee has no acquaintance or experience. An administrator must plan, organise and evaluate; it is therefore extremely unfair to place a person in such a position without pre-administrative training.

If a man is called upon to administrate with no other preparation than technical knowledge and skill, it will take much ingenuity on his part to be successful. If he does not succeed in acquiring by chance the ability to administer, his department will suffer from confusion, inconsistency and poor labour relations which will ultimately lead to its failure.

Modern industry recognises the necessity for pre-administrative training and many plants have introduced an Administrative Replacement Schedule which indicates when positions will be vacated through promotion, resignation, health or retirement. This permits considerable planning and pre-administrative training to be carried out for selected personnel.

The engineering industry is one of extreme complexity, with each plant having its own peculiar production problems; but irrespective of what plants produce, their pre-administrative training plans should be of similar pattern.

The first thing to define in advance is the method of selecting candidates. Next, plan their preparation so that they are ready when the opportunity presents itself. The programme of instruction should emphasise the following basic points:

1. functional terms of reference;
2. complete operation of the production control system;
3. the organisation of people into effective units;
4. handling of interdepartmental and labour relations;
5. planning of one's own work.

After the individual has received his pre-administrative training, he must be given every opportunity to discuss his experiences and problems with other people on the same types of work, and be kept up to date with information regarding rapidly changing modern techniques and developments.

principles, responsibilities and objectives

The success of a department depends on its strength of organisation, within which is contained strength of planning and controlling combined with harmony and flexibility. To establish such an organisational structure, it is necessary to lay down a broad policy as to the basic rules—which the administrator must follow—regarding principles, responsibilities and objectives.

The basic principle of administration is to accomplish results through the efforts of other people. To define this statement, let us consider the department as a whole. Within it are skilled craftsmen, technicians and engineers who require the direction of supervisors with the ability to command their respect and confidence. By virtue of his position, the administrator cannot be familiar with the necessary finer technical points required for this direction; his skill in this field has diminished whilst administrative competence has increased. To enlarge on the basic principle and assist in its interpretation: administration is not the direction of operations, it is the development of competent people to carry out that direction which organisational requirements dictate. The early stages of development of individuals will be taken care of by pre-administrative training, but theoretical instruction will not and cannot define the required skills of judgment and experience. The administrator must take individuals as they are, together with their technical knowledge, skill and background; by increasing their knowledge he must develop and release their latent potential to flow in controlled channels of supervisory competence, and successfully integrate them as a frictionless part of the organisational machine.

The prime responsibility of administration is to place organisational interests first, irrespective of any personal considerations. Decisions resulting from interpretation of this responsibility must be established without abuse of authority, and given in a clear straightforward manner. The administrator will assign responsibilities and delegate authority to attain planned objectives successfully, but he cannot pass to others responsibility for the overall success of his department.

The major objectives are harmony and flexibility. In the cause of harmony, it should be made perfectly clear to supervisors, foremen and section leaders that they are in effect the managers of their respective units; no one will usurp their authority or prerogative. As a team, all units have a responsibility to co-operate with each other to maintain a harmonious relationship with a high degree of teamwork, respect and collaboration. As units, they are expected to command the respect and confidence of every individual within their areas of operation, and to stimulate them to make the best use of their abilities.

Flexibility of thought and action must be recognised as essential qualities to be developed within the department. Individual initiative must be encouraged towards the development of new techniques for production application; by allowing intelligent interpretation of set procedures or policies, many problems will be solved at lower levels when unforeseen circumstances occur.

Friction is the natural enemy of organisational structure; it creates hostility and neglect, it disrupts teamwork and undermines authority, resulting in the loss of that personal influence necessary to the successful attainment of planned operations. Constant watch must be kept for signs of friction, the major cause of which is dominating agressiveness. If apparent, immediate corrective action must be taken or the cause eliminated.

organising (morale building, co-ordinating and integrating)

The administrator's function is to organise his depart-department to produce what is required when it is required, and at the lowest cost.

His industrial responsibilities can be defined under four main headings. Firstly, the general policies and instructions issued by management must be carried out in detail. Secondly, the administrator must recruit, promote, train and retain competent employees. Thirdly, he must instigate pride of workmanship, thereby maintaining a quality product

which will ensure customer satisfaction. Fourthly, he must help ensure the prosperity of the company by full consideration of the shareholders. If these four points are considered, a department can be said to be organised.

The key to organisational efficiency is good morale. When considering the different backgrounds of people it will be found that no two individuals are alike. To co-ordinate these individuals into groups and integrate these groups into a team with high morale, requires much attention and conscious application of the skill of leadership.

Leadership has three basic requirements. Firstly, to instil into the minds of the whole department the common aim — *Production* — within whose framework is contained the prospects of advancement and the prosperity of every individual in the organisation. Secondly, to create an harmonious department by fostering the spirit of *Mutual Co-operation* — not giving way blindly to every proposal that employees make, but by giving a fair and understanding hearing to their problems, and ensuring that reasons for decisions made are passed to the interested personnel. Thirdly, to give the department *Incentive* — for people work harder when they know rewards are available. An important part of incentive is commendation. This is a great source of encouragement to the individual, from which will result ever-increasing efforts to achieve still higher levels of efficiency.

Investment in human morale is a skilled operation requiring both experience and courage. It is very easy to believe that paying less than one should will result in money saved, but it is difficult to believe that paying full recognition means greater returns in the future.

Co-ordination is achieved by organising groups into efficient units of labour and resources with flexibility to overcome any unforeseen obstacles. Within the units, duties and responsibilities must be accurately assigned and all instructions precisely and clearly stated. The success of any co-ordinating plan depends entirely on the skill exercised by the administrator in the selection and development of his lieutenants.

Integration is achieved by establishing each co-ordinated group into an efficient and harmonious combination, with each playing its fitting part in the team to give a balanced whole. The successful integration of the co-ordinated groups is entirely the responsibility of the administrator, who, before deciding on any particular course of action, should discuss the problem with the people involved, to obtain their viewpoints, suggestions and opinions. After analysis of the points raised, a position will emerge which is fairly well assured to be a safe foundation on which to base a decision.

planning and controlling

The administrator has numerous duties to perform, most of which, when clarified, can be divided into the two basic elements, planning and controlling. The only reasonable and sensible approach to the many problems to be solved by the administrator in connection with the activities he supervises, is to plan in advance what to do and when. Once it is accepted that planning is necessary, the supervisor must then establish a system of control to assure that the personnel under his direction perform their duties according to the plan. It is recognised that humans have many frailties, one of which is that their performance can always be expected to be behind the planned schedule. To overcome this, control by supervision is established. If planning alone could set the necessary machinery in motion and deliver a finished article or project in accordance with the plan, then supervision would not be required in industry today.

It would be a failing on the part of an administrator if, on taking over a new position which already had a planning and control system that apparently ran reasonably well, he assumed that all was well. Any administrator can improve the effectiveness of his department if at regular intervals he will take time to analyse carefully his organisational structure. This will include giving extremely careful attention to the quality and methods of his supervisory staff. When satisfied with his findings, he will be assured that his department is effective and that he has the ability, through the strength of his personnel, to direct operations toward planned objectives.

Planning includes policy formation. Policies should be established to give guidance to all personnel as to plans of action. These will effectively inform them step by step of what to do to obtain the desired result when planned situations occur.

Controlling requires that adequate arrangements be made to provide sufficient assistance, and to keep information available so that personnel are able to perform the functions expected of them and to provide a reliable feedback of information on the department activities. Control efficiency is achieved by delegating responsibility and authority to people of the right calibre, who can be developed into effective mainstays of the controlling framework.

For successful planning and control techniques there are three vital points to which the administrator must adhere in order to obtain the required results. First : he must devise a plan or policy which clearly and precisely states in writing what objectives are to be accomplished. Second : he must establish a basic procedure which will accomplish the planned objective. Third : he must allocate responsibility and authority to individuals to ensure that the steps of the procedure are carried out.

philosophy (basic attitude and doctrine)

Since the Industrial Revolution there has been constant strife between labour and management, caused in the vast majority of cases by lack of organisational purpose in relation to the human factor. If insufficient emphasis is placed on human beings, the result is a cold efficient type of organisation, whose efforts will be met by the employees with resistance which eventually develops into strong opposition to the management attitude, thereby dividing labour and management into opposing factions.

So-called practical organisations still exist where it is thought that the introduction to the plant of a

philosophy giving adequate consideration to the human factor would be a sign of weakness, and give rise to sentimentalism. However, investigations and experiments, conducted by expert organisations interested in the effective management of industry, have proved that increased production and growth of enterprise flow from a stable labour position, where the organisational philosophy recognises and considers the human factor. Modern industry recognises that an organisation without such a philosophy is an organisation without a purpose. Companies are in business to obtain a profit, and employees of these companies work to obtain and improve on a reasonable standard of living. Both interests are indivisible; the company's growth, within which opportunities will occur for everyone, is the employee's growth. On this basic fact the purpose or philosophy of an organisation should be founded, and clearly defined and worded, so as to be understood by both labour and management personnel.

Philosophy applied to production engineering will obviously be guided by the basic philosophy of the organisation. It is the administrator's function to accept that philosophy, to interpret and develop it toward the good of the company. To this end, the key element to be developed will be the personnel spirit.

Development of the personnel spirit requires the administrator to recognise that people under him are human beings with dignity and self-respect. Genuine concern must be felt to keep dealings with these people honest, considerate and responsible. It must be openly advocated to the employees that the interests of the employer and employee are fundamentally the same, and that by wholehearted co-operation in the cause of enterprise labour benefits will result. The most important ways to create and maintain an harmonious atmosphere are: firstly, plan wherever possible to provide steady employment; provide opportunities for advancement to existing personnel before considering outside applicants; give proper consideration to employee criticism. In turn it should be established quite firmly with the employees that obligations are required from them; they must recognise the line of authority as set by the company, and that loyalty to the interests of the company and conscientiousness to the best of their ability are required from them.

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THE 1959 VISCOUNT NUFFIELD PAPER*

REPORT AND DISCUSSION

THE 1959 Viscount Nuffield Paper — the seventh to be presented since the Paper was established in 1953 — was given in the Rankine Hall of the Institution of Engineers and Shipbuilders in Glasgow, on 17th March, 1960, by Dr. C. Timms, M.I.Prod.E., Head of the Mechanisms, Metrology and Noise Control Division of The National Engineering Laboratory, at East Kilbride. The subject was "Recent Developments in Spur and Helical Gears", and a large audience of members and friends attended the meeting, for which the arrangements had been made by the Glasgow Section of the Institution.

Mr. H. W. Bowen, O.B.E. (*Chairman of Council*) presided over the meeting and in introducing him **Mr. G. V. Stabler** (*Chairman of the Glasgow Section*) said:

"It is usual for meetings of the Institution in Glasgow to be presided over by the Chairman of the Glasgow Section, who at the moment happens to be myself. This is not however, a 'Glasgow' meeting!"

"We are pleased to have with us on the platform Mr. R. W. Mackay, from Dundee, the Scottish Regional Chairman, but this meeting is more than a Scottish Regional Meeting. It is — I think for the first time in Glasgow — a full Institution Meeting, and the first time a Named Paper has been presented in Scotland, and I have pleasure in welcoming to 'Bonnie Scotland' Miss Dancer and Mr. Caselton, who have done so much for the Institution. We are also honoured by the presence of the Head of the Executive. I have pleasure in introducing to you your Chairman for the evening, Mr. H. W. Bowen, O.B.E., Chairman of Council of the Institution of Production Engineers."

Mr. Bowen, in thanking Mr. Stabler, said he was delighted to be present, and to take the chair at what was, after all, an historic occasion, and one of the major meetings of the Institution.

The Nuffield Paper was the second of the Institution's Named Papers to be established, in accordance with the wish of Council to honour some of its distinguished members who had given the Institution valuable service. Lord Nuffield was President of the Institution from 1937 - 1939, and it was largely due to his support that the Institution was able to establish, at Loughborough College in 1938, the Research Department which in 1946 was expanded into The Production Engineering Research Association of Great Britain.

It was with the greatest pleasure, said Mr. Bowen, that he introduced Dr. Timms, who was to present the seventh Viscount Nuffield Paper on "Recent Developments in Spur and Helical Gears".

(*Dr. Timms then presented his Paper, which appears on pages* 321 - 340 *of "The Production Engineer", June,* 1960.)

Following the presentation of the Paper, the discussion was opened by **Mr. T. H. O'Beirne** (*Barr & Stroud Ltd., Glasgow*) who said:

I feel honoured — and am somewhat surprised — to be a guest here tonight, invited to open your discussion. I cannot claim to be a production engineer, or even an engineer: I am a mathematician who tries to bring some mathematics down from the ivory tower into practical service in the market-place. In this process I meet engineers, and learn from them. Tonight is a case in point. Perhaps I may hope to give something in return.

The mathematical content of engineering problems varies considerably, and this is true of gearing problems in particular. They invade the domain of the physicist and require consideration of noise, lubrication, heating, shock, plasticity and fracture, in regard both to the initial production and the subsequent performance. This is pre-eminently true for the large turbine gears which are the foundation of much of Dr. Timms' work.

I might have expected this discussion to be opened by someone with related experience in practical shipbuilding. Possibly something more of a contrast is wanted. My own experience is with small gears, where these questions are of reduced importance. Frankly, I am glad enough of this: there remain other problems of quite sufficient difficulty.

Over 10 years or so, my principal experience has been with the introduction of methods of manufacture of small curved-tooth bevel gears, and with the attainment of an increasing degree of precision both for these and for simpler types of gears. Success here has involved contributions and collaboration from my engineer colleagues, whose aid I needed as much as — or more than — they needed mine: but neither alone would have sufficed. In the spur gear work, acknowledgment is due to external assistance from the study and co-operation which has lately culminated in the publication of an Admiralty book of

* "Recent Developments in Spur and Helical Gears", published in "The Production Engineer" June, 1960.

Mr. H. W. Bowen, O.B.E., Chairman of Council (second from right) is welcomed by Mr. G. V. Stabler, Glasgow Section Chairman (second from left). In the centre of the group is Dr. Timms, and on the extreme left and right, respectively, Mr. S. Caselton,Deputy Secretary of the Institution, and Mr. R. W. Mackay, Scottish Regional Chairman.

reference on gearing. I understand Mr. Timbury intends to refer to this in more detail.

It may be enough to reiterate what is implicit in Dr. Timms' Paper — it is actual failure in a set task which gives the real spur to improvements. He who wants improvements for their own sake is apt to be told, "let well alone". Yet our hardest task-masters can be our greatest benefactors.

There are two other conclusions from our experience. You will in time be forced to make every improvement you can think of, and most of them will have a quite noticeable effect: you had better try them voluntarily, early, rather than later, perforce. Also, it is vital to have actual instrumental recording. When everyone can clearly see improvements taking place, morale and performance improve all the way down the line. Faults can no longer be blamed on gears when responsibility actually lies elsewhere. Moreover, a complete record contains more information than a remembered or recorded maximum dial recording; it can sometimes point to deficiencies in the machine when otherwise the operator might unjustly be blamed.

I would myself think that the best small-pitch machines are fairly satisfactory at present. Their makers will allow acceptance tests based on standards which appear realistic in relation to errors elsewhere involved. There is some tendency to strain at gnats in gear tolerances while swallowing camels in the way of bearings, mountings and auxiliary components.

In complicated mechanisms proof of this occurs when the occasional emergency discloses that a nominally deficient gear produces no noticeable deterioration of performance. Here, at least, further improvement of gears is not the most economically urgent objective, and efforts can better be diverted temporarily to produce improvements elsewhere. There is useful work to be done while we await the availability of feedback hobbers for small gears.

Gearing is notably liable to the overspecification which derives from ignorance. This ignorance is at times inevitable: more often it is culpable. It is much easier to write "no backlash" and then either assert — or deny — that you have got it, than to set the limits you actually need, and to test impartially that you get accuracy neither much less, nor much more. This seems to me the essence of production engineering.

In many instruments, good design requires a pair of extremely accurate gears at one end, to produce a velocity-ratio such that errors elsewhere in a complicated train are of lesser concern. Note is taken of this in specifying different classes of gears in the two cases, and in allowing less stringent precautions or use of less accurate machines where appropriate.

I am rather out of sympathy with the present practice of hoping to apply identical inspection procedures, differing only in the allowable tolerances, in the two cases. These require master gears, or worms, intended to have negligible errors. These masters are not always available with the accuracy required for the highest class of gearing: nor indeed is this to be expected.

choice of inspection procedure

If you need only have gears which can have 10 times the error of the best possible gears, it may well be both feasible and efficient to have the latter as master gears and neglect their errors, using rapid inspection procedures. If instead of a factor of 10 you have only two, or three, you must either allow for the error of the masters, or, preferably as I think, determine the errors of your gears by more complicated and skilled inspection procedures, namely, those which are in fact applied to master gears themselves.

There will be fewer of the accurate gears than of their lower-class associates. It is quite unreasonable, and unnecessarily restrictive, to demand equally simple inspection for both.

Some trouble could be saved, particularly in the extreme precision field, if there were more awareness that every demand for unnecessary precision reduces the accuracy that can be given where it is really needed.

If gears could be matched in a definite mesh, in truly conjugate pairs — as proved on test with a grating-type of instrument, for instance — this would often suffice unless there were unusual interchangeability requirements. Hobs could then have a useful tolerance for pressure angle, and firms could more easily make their own for instrument work.

The grating-type tester would thus give a useful check on cumulative pitch, which is rather impractical for small gears at present. Not uncommonly, tolerances here are rather irresponsibly specified, and often are never inspected by anyone. The formidable difficulties of inspection are faced only intermittently, at best, or initially, as a precaution that the machine is free from errors which would not show up in production double-flank testing.

Some of these problems must be much simpler when a firm manufactures only for itself and not for

external customers. It often seems to me that what is needed generally is not so much the extension of existing knowledge — important though this is — as the effective dissemination and utilisation of existing knowledge.

In my experience, even at present, if I meet an outside drawing or an outside part with a spur gear of 13 teeth or less, I expect it to be undercut, and am seldom wrong. Pursuing the matter leads to " the prototype has been made and approved, and the drawings can't be changed now " or alternatively to " we told the customer and he said it didn't matter ". I suppose the situation must be better in other fields, where performance and cost depend more obviously and directly on the gears. The Admiralty memorandum has given us a lever by means of which we can produce some improvement here.

In this connection I am more aware of deficiencies than of excellences in British Standards. Here I speak not of the standards for machines and cutters, but of the basic standards for gearing. Had these been what they ought to have been — and what other British Standards are — no Admiralty memorandum would have been needed to supplement or by-pass them.

Their principal defect is that much too much is left out. Neither the Americans nor the Germans try to pretend gearing questions are simple, by leaving out what might be thought to frighten the ordinary man. It would be better if he was given more cause to feel frightened, and better still if he was properly assisted to avoid frightening others. At present when he quotes a British Standard, it is more likely than not to be the wrong one, for fine pitches, and there are other sources of trouble. Blanks are often wrongly specified, and sometimes manufactured in quantity. Short of doing the whole job properly, it would be better if the customer specified only pitch surfaces and performances, and was discouraged from meddling with the rest.

scope for improvement

I must say that I think the major improvements needed in the field of gearing are organisational rather than technical, and that the main cause of trouble with gears is — people.

Some of the difficulties arise from divided effort, and much might be expected of a national Gear Centre of the type advocated by Dr. Timms. British machine tool manufacturers are not noted for the size or scope of their research departments, and they have little incentive to objective study of methods which do not use their own machines.

Dr. Timms must indeed be complimented on what he has done with the resources he has. I have no wish to suggest he has done other than direct his efforts where their need is most urgent, and where they best may bear useful fruit such as we have seen tonight. At the same time, I remember that I first met him at N.P.L. some eight years ago when I was seeking information on bevel gearing. His department did not handle bevel gears then, and does not do so now.

For bevel gears the United Kingdom is dependent on foreign manufacturers not merely for machines, which once obtained are at least thereafter available, but in many cases for cutter and machine-setting information as well. This may just be acceptable in large production runs. It is a barrier to proper development work.

We have done something to free ourselves from these limitations in my firm : at the same time we receive outside designs which obviously are tailored to suit about a dozen known bevel-gear combinations.

a new type of technologist

Reducing this somewhat adject dependence will require the emergence of a new type of engineering technologist, who will need high qualifications in mathematics. In the past, the mathematicians worked out much of gearing geometry before the engineers were ready for them, and mathematics is available — not yet applied, unless by a mere handful of unique individuals — for study of such matters as contact and curvature of designedly crowned teeth, effects of relief and helix angle cr hob profile, and many similar matters which I feel are not at present studied as much as is desirable. Hypoid gearing developments arose this way; it may be doubted whether even now some of these are fully understood by anyone other than their original inventor and a few personal associates.

In my view, there is a need in mechanical engineering for high mathematical talent—either imported, or locally grown — quite as much as in electrical engineering, where the need is fully admitted and recognised. What I doubt is whether this view is held sufficiently by those who control the employment and education of mechanical engineers.

At present the engineers and mathematicians can discuss identical questions in complete isolation. The " involute helicoid " of the one is the " developable helicoid " of the other, and few indeed know the subject in both forms, realising that both these surfaces are identical, and important for basically the same reason in both fields of work.

A national Gear Centre will have to face these facts and do something about them. If it is merely a correspondence exchange superimposed upon existing establishments, it will only scratch the surface of the real problem.

Reference has been made to dependence on foreign firms who have a virtual monopoly of certain types of high grade equipment. It may well be no coincidence that most of these are noticeably provided with one or more technologists of the type I have just described.

Until a similar situation exists in this country, with users and manufacturers alike, it seems likely that Dr. Timms will continue to have something of an uphill fight. We must all be grateful that his enthusiasm and successes nevertheless continue unabated.

Mr. W. P. Kirkwood (*Albion Motors Ltd., Glasgow; Past President, Glasgow Section*) : The survey by Dr. Timms has indicated that very considerable

developments have taken place in spur and helical gears over the last decade. Personal contact with gears over this period in the small and medium-sized range indicates that there is still much to do.

In testing, the developments with a single flank tester are awaited with interest. This should be more rewarding than the dual flank method in being able to pick out unsatisfactory gears, although this latter method has served industry well. Can the author indicate when practical workshop instruments working on a single flank are likely to be available ?

Temperature control is given a prominent place. Experience indicates that not only control is needed but that modern machines to get accurate gears must be brought to the working temperature before gears can be machined. It is suggested that on all such machines the manufacturers should incorporate heating coils at suitable positions, so that where gear cutting is only carried out on one shift the machine can be left with the heaters on during the night, and therefore ready for accurate work in the morning. It is not in keeping with 1960 that machines cannot be put into immediate action at the beginning of a shift.

use of diffraction gratings

The use of the diffraction gratings for the measurement of gears dynamically and for the control of the machines is probably one of the biggest steps forward in the last few years. Much of the credit is due to the work which has been put in by the author personally and by his staff at N.E.L.

Although measurement is undoubtedly the first application of diffraction gratings, their use to make the correction on the machine automatically is of such great importance that it is obvious that a solution to the problem of accurate production of gears by this means may be within our grasp. Can the author indicate whether we are likely to see machines involving this principle available for special purposes in the near future ?

The causes of noise in the running of gears have been under examination for many years without apparently being able to determine accurately the effect of the various features contributing to the noise. There is no doubt that under certain conditions improved accuracy can mean reduction in the noise level. On the other hand, the curves in the Paper given under Fig. 29 show that at certain frequencies, there seems to be little or no difference between the level of noise produced between a hobbed gear and a shaved gear. In a number of cases the major source of noise would appear to come from the impact caused by the teeth coming into contact with each other. This has been proved in automotive applications, where the change over from straight spur gears to helical gears within the same gearbox has resulted in a very considerable reduction in noise, the gears in both cases being made to the same standard of accuracy. Has the author any views on this particular aspect ?

One point not mentioned at all in the Paper is the great change that has taken place in the last few years in the rate at which it is possible to hob gears. On a production basis such modern gear hobbers can produce satisfactory gears working at cutting speeds more than double those possible only a few years ago. This has been achieved by improvements in machine rigidity and other factors brought about in the redesign of machines over the period in question. This achievement is in its own way as important as the other advances, particularly in accuracy, which have been made over the same period.

Mr. J. R. Young (*G. J. Weir Ltd., Glasgow; Glasgow Section Committee*) : First of all, I applaud the call for criteria as to what constitutes surface failure by both pitting and scuffing.

We have to face the fact that, industrially, most decisions taken are based on opinions and opinions vary pretty much as to whether one represents the user or the manufacturer.

The figures shown for average percentage contact marking on test gears produced to three standards of accuracy (Fig. 24) came rather as a surprise. A difference of only 6% between precision and commercially hobbed gears is unexpected, and one wonders whether it means that considerable improvement has been achieved in commercial hobbing, or whether there is still scope for further improvement in precision hobbing machines.

Mr. M. C. Timbury (*Barr & Stroud Ltd.; Past Chairman, Glasgow Section*) : Dr. Timms' very excellent Paper covers such a wide field that comment by any one person must be confined to that part of the subject with which he is most conversant.

For this reason I would like to make a few remarks about the production of small gears, used in precision measuring and recording mechanisms, a line of business with which I have been associated for many years.

Towards the close of his Paper, Dr. Timms remarked upon need for closer co-operation between the gear industry and instrument manufacturing firms and gave as his opinion that the manufacture of gear instrumentation in the United Kingdom is carried out on " a piecemeal basis ".

While agreeing in general with Dr. Timms' views, I would point out that the number of firms manufacturing small precision mechanisms which call for really high quality gears is limited. The cost of manufacture of such gears is high and the cost of manufacturing suitable equipment for testing them is also very high, not only because of the precision demanded but also on account of the limited market.

This does not offer an attractive proposition for anyone to undertake on a commercial basis, and possibly explains Dr. Timms' opinion that " it is regarded as a side line by too many firms ".

The manufacture of spur and other gears for precision mechanisms has undergone a very radical change in the last few years, and this change has been due to the demand for greater precision necessary for the mechanisms used for the control of modern weapons.

In 1953 the Admiralty issued to certain firms a " Specification of Gearing for Gunnery Equipment " which laid down for the first time standards of accuracy for gearing for various types of mechanisms. Of these standards Class I and Class II were for gears for use in predictors and similar applications where great relative rotational accuracy is necessary. In the case of Class I an allowance of .0003 in. was specified for tooth to tooth accuracy with .0007 in. for total composite error, measured on a double flank tester.

The views of contractors on the practicability of these standards were invited before the specification would be adopted.

This presented a challenge to the gear cutters and set into being a vast amount of experimental work.

For the first time, a requirement was laid down that each gear must be tested on a double flank tester and the results recorded graphically.

I will not go into the difficulties that were encountered in obtaining master gears, not the least of which was their costliness, but will say that the master gear was replaced largely by the master worm for testing purposes.

It became apparent, as the investigations proceeded, that the production of a precision blank was an absolute necessity if the requirements of the proposed Specification were to be met. This confirms Dr. Timms' early remarks.

In the production of the blanks two essentials arose :

1. The necessity for a lathe free of any camming action in the spindle so that back face squareness on the blank could be achieved; the permitted error being .0004 in. per inch of radius.
2. Accuracy and consistency in the diameter of the bore.

Having achieved both of these the next essential was to ensure accuracy of the mandrels. This necessitated the selection of a grinding machine capable of producing a really straight and round job, say, to a tolerance of .0001 in. maximum.

I do not propose to discuss the relative merits of different methods of producing accurate bores, but one method is by broaching and experience has shown that a consistency of less than .0001 in. can be achieved by this method.

This brings me now to another of Dr. Timms' conclusions, viz., " There is a need for improvement in the accuracy of gear cutting machines in the small and medium range."

Having produced blanks which were really accurate, much difficulty was experienced due to errors resulting from inaccuracies in the gear trains of various gear-shaping and gear-hobbing machines.

Machines just delivered by the makers had to be dismantled and rebuilt, but I know of two British machine tool makers who tackled this problem and produced a much improved machine. Machine tool makers could with advantage investigate the application of optical gratings to check the accuracy of their machines. Further developments in work holding facilities are still necessary.

This toning-up of gear cutting techniques has been most beneficial and a number of firms are now producing, regularly, gearing to the requirements of this draft Admiralty Specification.

The effect has been to achieve what was intended, namely, to produce gears which can be assembled directly into mechanisms without any form of hand manipulation and has been given results previously thought to be impossible.

The Admiralty Specification has now been adopted. It is known as the "Admiralty Gearing Memorandum Ref. No. B.R.6001(1) " and can be purchased from H.M. Stationery Office.

I consider it to be a valuable book of reference.

It is said that " necessity is the mother of invention ". Certainly the introduction of this document was responsible for many " Recent Developments in Spur and Helical Gears ".

While agreeing with Dr. Timms on the importance of the provision of high quality devices for the measurement of errors of all kinds in gears, it must be remembered that these devices do not correct the errors, and for this reason machine tool manufacturers must apply the highest possible standards to any gearing incorporated in their machines if the problem of producing high quality gears is to be satisfactorily solved.

In conclusion, I would state that the cost of precision is very high and presume to point out to designers that the adoption of standards, such as required by Class I gears, where they are unnecessary or can be avoided, is an unwarranted addition to the cost of production.

Replying to the points raised, **Dr. Timms** said he appreciated the detailed observations made by **Mr. O'Beirne** and was in general agreement with the comments made. The need for graphical presentation of gear errors was stressed by Mr. O'Beirne and the provision of inexpensive recording units, referred to in the Paper, would have wide application in metrology generally.

The point made concerning the availability of master gears of the highest precision was important and it was logical to relate the accuracy of the master to that of the product gear. This requirement could be met by having two grades of master gear, one to cover general commercial applications and the other for gears in which the highest precision was essential. It was also agreed that selected product gears of the appropriate standard of accuracy could be used as master gears in many applications.

The further point raised by Mr. O'Beirne concerning the need for a new type of engineering technologist was an interesting one. This subject was basically one of education and it was significant that no University in the United Kingdom covered the subject of engineering metrology at the same level as other branches of mechanical engineering.

In reply to **Mr. Kirkwood**, the application of the moiré fringe technique to the correction of residual errors in machine tools was still in the early stages of development but the initial results obtained to date were most encouraging. Commercial development in

Mr. Bowen, Chairman of Council, making the presentation of a silver rosebowl to Dr. Timms.

this field would depend on co-operation with the machine tool industry.

It was generally agreed that the change from spur to helical gearing resulted in an overall reduction in noise level. This was associated with improvement in the uniformity of the tooth action arising from the overlapping effect of adjacent helices. Although not specifically mentioned in the Paper, the point concerning the machine rigidity was quite clearly very important and required detailed consideration at the design stage in order to achieve and maintain the required standard of dimensional accuracy.

Similar remarks applied to the methods used for the stress relieving of castings and the heat treatment of machine tool elements such as feed screws.

Regarding the point raised by **Mr. Young,** a difference of only 6% in contact marking between precision and commercial hobbed gears was largely due to the difficulty in obtaining accurate tooth profiles for each hobbing process. In each case there was definite evidence of split marking which could arise from errors in hob mounting or cyclic pitch errors in the hob.

Mr. Timbury's observations related in the main to the measurement and control of fine pitch gears where a high standard of accuracy was required. It was agreed that the present market for this quality of gear was limited, but the demand was likely to increase with expanding interests in automatic control systems for measurement and machine tools. Similar remarks applied to the availability in the United Kingdom of high precision measuring equipment, and an increase of interest in this limited but important field would reduce our dependence on foreign sources of supply.

Mr. R. W. Mackay (*Scottish Regional Chairman*), who proposed the vote of thanks, said : " This is a very great pleasure and, indeed, an honour, to have been called upon to propose the vote of thanks to our speaker this evening. You have shown by your attention to Dr. Timms, who gave a very good exposition of his subject, that you were with him in these problems as presented. Your questions concerning the problems incurred in gearing from manufacture to use have confirmed this, if, indeed, any confirmation were necessary. This meeting marks a milestone in the history and development of The Institution of Production Engineers.

" It is my very pleasant duty to ask you to express your warm and sincere appreciation of the speaker in the usual manner."

The Chairman of Council, making a presentation to Dr. Timms, said : " It is now my very pleasant duty to present, on behalf of the Institution, this beautiful rose bowl to Dr. Timms. We thank you for your lecture. We think it was marvellous. You have, by giving this lecture, contributed another step forward in the progress of the Institution in Scotland. Thank you very much indeed."

The proceedings then terminated.

BUSINESS SIMULATION EXERCISES **— concluded from page 426**

" The General Electric Company Business Games." Management Consultation Services, 570 Lexington Avenue, New York, 22.

" The Andlinger Game." Harvard Business Review, Soldiers Field Station, Boston 63, Mass.

" American Bell Telephone Game." Robert L. Boger, American Telephone and Telegraph, New York, N.Y.

" Computer Game." University of California, Los Angeles, School of Business Administration, James R. Jackson.

" Management Decision Making Laboratory." International Business Machines (United Kingdom) Corporation.

" Carnegie Tech. Management Game." Carnegie Institute of Technology, Graduate School of Industrial Administration, Pittsburgh 13, Pennsylvania.

The following are available as preprints of Papers presented at the 6th Annual International Meeting of the Institute of Management Sciences, September, 1959, Paris. Printed in great Britain by Pergamon Printing and Art Services Ltd :

" Business Gaming in Management Science Education " by James R. Jackson.

" A Decision Game of Managerial Strategy as a Research Tool " by Torben Agersnap and Erik Johnsen.

" Contributions et Experiences de ' Management Games ' " by M. M. Aubert, Bourges, Minth et Anstett de la Compagnie Francaise d'Organisation (CoFrOr) and J. B. Tricaud de la Societe d'Automatisme Electronique et de Recherche Operationnelle (AERO).

BATCH PRODUCTION:

New Approaches to Problems of Factory Control

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This Paper was awarded the 1959 S.E. Region Prize for the best Paper submitted by a Student or Graduate of the Region. Details of the 1960 Competition appear in the Supplement to this Journal.

Mr. Ward, who holds an Honours Degree in Special Physics, was educated at Gresham School and completed his National Service in the Royal Air Force, as a Radar Supervisor. He served a Graduate Apprenticeship in Production Engineering with his present Company.

THE principal problem of factory control * in batch production is to assign specific operations to specific sections at specific times at specific rates. In large scale batch production, involving the concurrent production of thousands of different assemblies, the problem becomes extremely complex with many varying parameters to consider, and the proper solution must significantly influence the profit position of the company concerned. The purpose of this Paper is to investigate some of the control problems inherent in batch production in the light of new management aids such as operational research, cybernetics and electronic computers.

1.1 description of a generic batch product

Fig. 1 shows a typical unit U_1 assembled from sub-units U_2, U_3, U_4 and U_5, each of these sub-units being assembled from further items U_6 to U_{19}. It must be noted that the size of the units in Fig. 1 has no significance. The various sub-units and items may be manufactured by the performance of a sequence of operations on raw materials, or purchased as a complete sub-unit or item. Obviously the sub-units U_2 to U_5 must be completed before the assembly of U_1 may be commenced. It is assumed that the production drawings for the assembly U_1 are arranged to enable the unit, sub-units and items U_1 to U_{19} to be completed as shown in Fig. 1. It is also assumed that the assembly must be subjected to the requirements of a test specification before it may be regarded as ready for despatch.

* The writer, for reasons expressed later, prefers the use of the term factory control in place of the term currently used, production control.

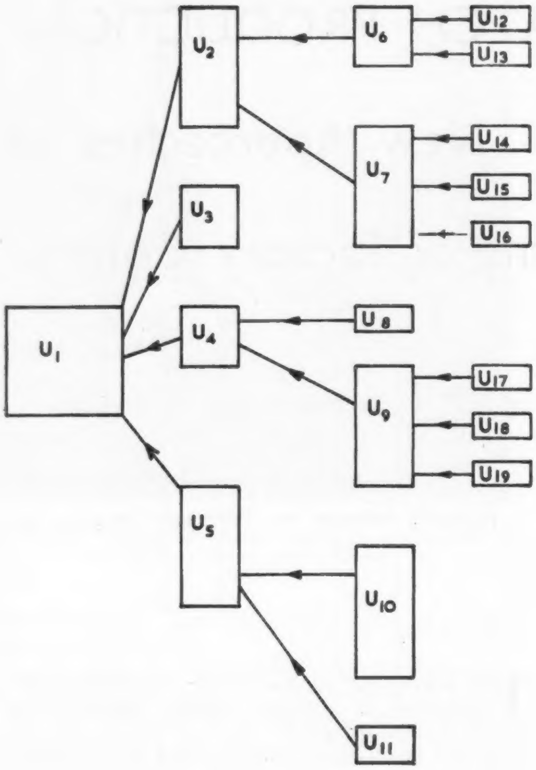


Fig. 1. Schematic diagram showing generic batch production assembly

1.2 description of a generic factory organisation

Fig. 2 shows a possible generic factory organisation designed for the batch production of a large range of assemblies of the type described in 1.1. It must be stressed that Fig. 2 is not exact or complete. Only those sections and flow channels required to illustrate various concepts to be developed later are shown. In principle these concepts will be common to all organisations involved in batch production, although the section and flow channels must vary in detail with the type and diversity of the production in which the integral organisation is engaged.

To illustrate the functions of the various sections, the flow of an individual order through the organisation will be considered. The following assumptions will be made:

1. That the Sales Department have established an order for a new design of one of the company's products and allocated an order number to identify it.

2. That the total quantity, date and rate that delivery are required has been established by the Sales Department in conjunction with the customer. The Sales Department's decision must, however, obviously be influenced by the production control centre in view of the forward factory loading.

3. That the possibility of modifying the forward factory load to accommodate the new order in a different manner will not be considered at this stage.

4. That all production drawings are available.

The flow of an order through the organisation will be as follows:

1. The unit break-down section will break down the assembly U_1 into sub-units and items, raising action documents instructing the Methods and Purchasing Departments to methodise and purchase manufactured and purchased items respectively (for control of Purchasing Department — see paragraph 6).

2. The Methods Department will produce the source of the action documents required to produce all the manufactured items required to complete U_1.

3. The Ratefixing - Work Study section will estimate times needed to manufacture all items required as methodised in paragraph 2 above.

4. The Clerical section will produce actual documents, e.g., travelling cards, job tickets and warrants.

5. The Production Scheduling section will provide the dates at which the action documents will commence in accordance with a master plan, details of which will be given later. This section will also provide the Progress section with a sub-master plan for the individual order.

6. The Progress section will issue and endeavour to control all the action documents to the sub-master plan of the order. As each operation is completed to the instructions of the action documents, information will be fed back to the Progress section. This information will be normally fed back by duplicate copies of the actioning document. If individual units or items fall behind the plan, expediting action or modification to the delivery, forecast by the plan, will be carried out by the Production Control centre. The Progress section will also endeavour to control the assembly U_1 through the Test section and Packing Department.

1.3 formulation of control problems to be considered

In order to appreciate the complexity of the problems facing the Production Scheduling section described briefly in 1.2, paragraph 6, it is necessary to consider the situation shown in Fig. 3. The chart shows the manufacturing operations required to be carried out on U_2 to U_5 in order that they may be completed ready for the assembly operation to form U_1. The notation used is as follows:

$$ {}^{q}_{n}U_p \qquad \text{where } p = \text{unit number}, \quad q = \text{operation number}, \quad n = \text{section number} $$

It is assumed that each operation is discrete, and no two operations may be carried out in one section simultaneously. Thus unit U_2 has three different manufacturing operations to be carried out in the sequence ${}^{1}_{1}U_2$, ${}^{2}_{2}U_2$ and ${}^{3}_{3}U_2$. The length of each operation time cycle will obviously vary and is indicated in units of time on the horizontal axis. Consider the following points:

1. The chart shows a possible schedule for completing the items required in a given manufacturing cycle of 13 units of time. It will be seen that ${}^{1}_{1}U_2$ and ${}^{3}_{1}U_4$ are both completed at the same time and the following operation for both U_2 and U_4 is designated to Section 2. In this case the "decision" required to obtain the minimum or optimum overall time cycle is simple, and this arrangement shows the optimum.

2. The schedule is based on the fact that the individual operation time cycles are accurate. However, if ${}^{2}_{1}U_3$ takes two units of time longer to complete due to a tooling problem or an error on the part of the Ratefixing section, then ${}^{2}_{2}U_2$, ${}^{3}_{3}U_2$ and ${}^{2}_{2}U_4$ are all delayed by varying amounts. If this occurred the schedule would have to be revised and a new optimum condition ascertained for the schedule to be of any future value.

3. Since at Section 2 at time 7 both ${}^{1}_{1}U_2$ and ${}^{3}_{1}U_4$ are waiting to have their individual operation performed the section could be described as having a "queue" of one item, in this case ${}^{3}_{1}U_4$ "waiting" for its individual operation.

It will be seen from the above considerations that if the simple problem illustrated is expanded to that required to represent a typical large scale batch manufacturing organisation, the production of a detailed schedule into the future would be pointless, since it would have to be continually revised and re-optimised to be of any value. This process would be impossible in view of the exceedingly large number of possible combinations.

A detailed study of this overall scheduling problem and a suggested solution forms the subject matter of

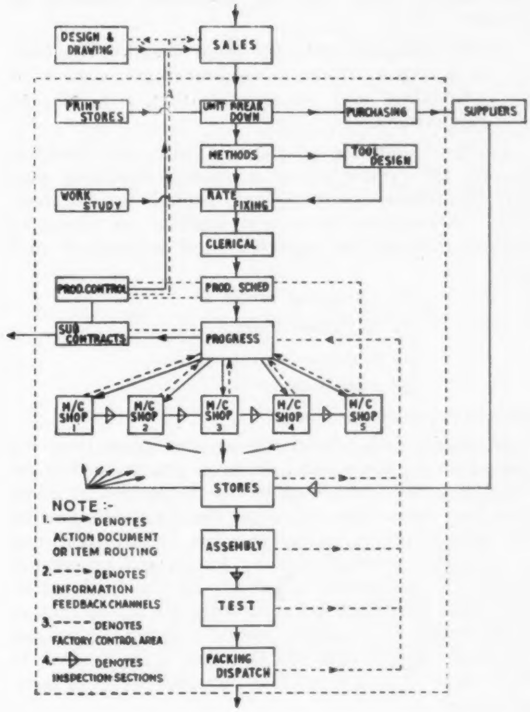


Fig. 2. Schematic diagram of generic factory organisation

SUB UNIT	OPERATION SEQUENCE
U_2	${}^{1}_{1}U_2$ ${}^{2}_{2}U_2$ ${}^{3}_{3}U_2$
U_3	${}^{2}_{1}U_3$
U_4	${}^{3}_{1}U_4$ ${}^{2}_{2}U_4$
U_5	${}^{1}_{1}U_5$ ${}^{3}_{2}U_5$ ${}^{1}_{3}U_5$

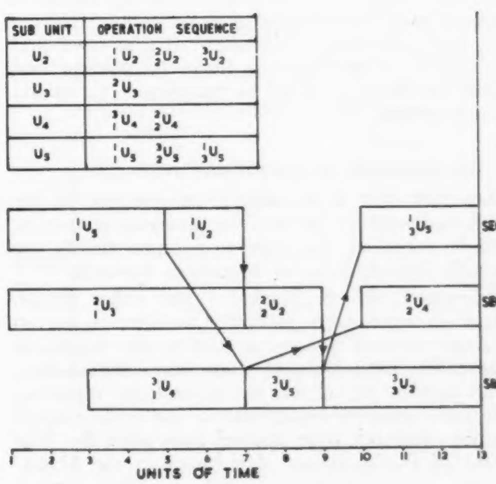


Fig. 3. (See Section 1.3.)

this Paper. This may be expressed formally as follows:

"The optimisation by the use of decision functions of a system subject to random interference in its scheduling and whose scheduling has inherent randomness."

Current methods of dealing with this problem involve the production of a master scheduling plan into the future as orders flow through the organisation. Allowances in section loading are made by various methods for unprecedented occurrences such as:

(a) ratefixing errors;
(b) defective work;
(c) machine maintenance;
(d) absenteeism;

based on past experience.

If orders fall behind the master plan they are placed on a priority, and items on priority orders are brought to the front of queues in the section in which they find themselves. This has the disadvantage that low priority orders become overdue. Detail scheduling is currently accomplished by haphazard procedures which are inadequate to predict section load bottlenecks and their corresponding reflection on the factory organisation as a whole. Whilst current techniques may seem logical and effective they often amount to little more than a continual scramble to meet commitments.

It is obviously desirable that control should be such that orders may be passed through the factory to a given schedule, that dictated by customers' requirements. For this purpose a scheduling system must be dynamic so that it may be capable of adjusting itself to unprecedented occurrences. Current procedures are in existence, the writer considers, due to the lack of decisions taking into account the actual situations at the time when the decisions are made. It is thought that the problem will only be overcome by means of an operational research type of investigation resulting in the use of electronic computers. It is stressed that the problem is essentially a research problem and research techniques must be employed to obtain optimum results.

2.1 introduction to operations research

Since Part 2.2 is essentially an analysis of the operations research type into the problems of queues, it will be useful at this stage to consider briefly the aims and characteristics of operations research.

Professor P. M. S. Blackett [1] and other British research scientists were probably the first to set up operations research groups as such at the beginning of the 1939 - 1945 War, to study problems of anti-aircraft gun fire power and the control and reporting of the early warning radar system. The techniques of operations research were applied soon after the War to some of the problems of industry in the U.S.A. and the nationalised industries in the United Kingdom, and are now being utilised on an increasingly large scale.

Operations research, the newest of the scientific aids to management, has been defined by Johnson [2] as possessing the following characteristics:

1. research on the operations of the whole organisation;
2. optimisation of operations in a manner that brings about greater assurance in both short and long range health for the organisation;
3. application of the newest scientific methods and techniques;
4. synthesis and extension of methods and techniques of the older management sciences;
5. development and use of analytical models in the manner common to the basic sciences;
6. design and use of experimental operations that give an insight into the behaviour of actual operations;
7. use of integrated and creative multi-disciplinary team research to solve complex operational problems.

2.2 a detailed analysis of queueing problems

The problems of queueing are common to many branches of life, from service in a supermarket to problems of saturation at a telephone exchange. The fundamental nature of the reasons for the occurrence of queues is important since, as will be shown, this feature will occur at all the service points and information feedback points shown in Fig. 2.

The pioneer investigator was Erlang [3], who in 1908 did work of a most fundamental nature on telephone switching for the Copenhagen Telephone Company. Since then much of the work has been conducted in the United Kingdom. The work has a common subject matter — that of delays encountered at a service point.

In a queueing situation the following components can be assumed:

1. items requiring a service;
2. service point;
3. service operation.

In other words, the components imply that items should arrive at a service point and as each moves to the service point an operation is carried out; after this operation is completed the particular item is usually of no further interest in the situation considered. Whilst the item in question undergoes a service operation the other items must wait in a queue. Thus the elements of interest are:

1. waiting time of items in the queue;
2. number of items in the queue;
3. service operation time.

Before a detailed analysis of the simple single service point queueing problem can be commenced two parameters must be considered:

1. how much later does an item requiring a further operation arrive than its predecessor;
2. how does the service operation time for each item vary.

As has been shown in Part 1.3 neither of the above parameters can be accurately given values, due to the statistical variation in predicted times caused by unprecedented occurrences. In the case of batch production the predicted times would vary naturally according to a distribution law for both parameters. To determine the actual distribution law a statistical analysis would be required, based on actual observation at each service point. The results would then be compared with results predicted by theoretical functions to determine the function possessing the greatest correlation. It will be assumed here that both parameters have a Poisson distribution [4] since this is generally found to be applicable and provides a simpler mathematical solution. The following solution is for an unspecified distribution law until the Poisson distribution law is introduced.

Consider the following:

1. Let t_r be the time interval between the arrival of the r^{th} and $(r+1)^{th}$ items.
2. Let s_r be the service operation time of the r^{th} item.
3. The t_r are independent random variables with identical probability distributions and the mean, $E(t_r)$, is finite.
4. The s_r are independent random variables with identical probability distributions, each mean, $E(s_r)$, being finite and being independent of t_r.

Whilst an item's arrival and service operation time are independent of the others, its waiting time is not. It is equal to (the waiting time of its predecessor) + (the service time of its predecessor) — (the difference in their arrival times) or zero if this sum is negative.

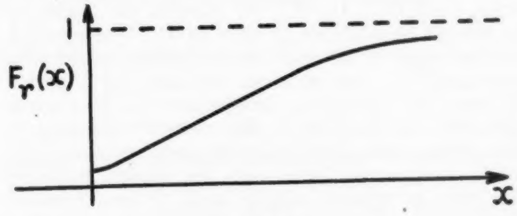
(i.e.) $w_{r+1} = w_r + s_r - t_r$ if $(w_r + s_r - t_r) > 0$
$= 0$ if $(w_r + s_r - t_r) \leqslant 0$

where w_r is the waiting time of the r^{th} item.

Let a new function $F_r(x)$ be defined as follows:

$F_r(x) =$ (probability that $w_r \leqslant x$) $= p\,(w_r \leqslant x)$

This function will be of the form shown below on Graph 1.



Graph 1.

as $x \to \infty$, $F_r(x) \to 1$
as $x < 0$, $F_r(x) = 0$
as $x = 0$, $F_r(x)$ may have some finite value

(i.e.) $F_r(0) = \mathrm{p}\,(w_r \leqslant 0)$

This is the probability that the r^{th} item will not have to wait. In general there will be a different F for each r, but each depends on the previous one and the distribution $F_{r+1}(x)$ can be found if $F_r(x)$ is known.

(i.e.) $F_{r+1}(x) = p(w_{r+1} \leqslant x)$

but $w_{r+1} = \left\{ \begin{array}{l} w_r + s_r - t_r \\ 0 \end{array} \right\}$

$\therefore \quad F_{r+1}(x) = p\,(w_1 + s_r - t_r \leqslant x)$

Now let $v_r = s_r - t_r$

which has a probability distribution $G(U_r)$ such that

$F_{r+1}(x) = p\,(w_x + u_r \leqslant x)$

$= \Sigma$ (probability that $w_r \leqslant x - u_r$) . u_r (probability of that w)

$$= \int_{u_r \leqslant x} F_r\,(x - u_r)\, dG\,(u_r)$$

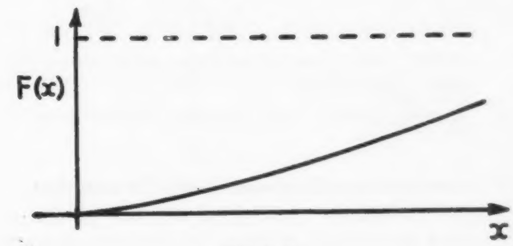
In this case one can pass to the limit of infinite r, so that the limiting case is:

$$F(x) = \int_{u \leqslant x} F(x-u)\, dG(u)$$

The quantity $F(x)$ contains all the information about the behaviour of the waiting line. It should be noted that the significant quantity is u the difference between s and t, and its distribution.

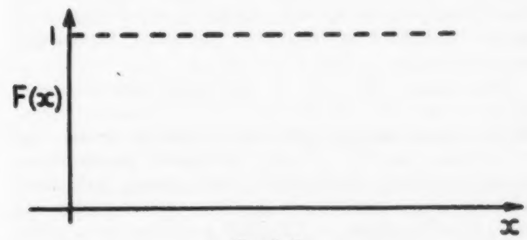
Consider $F(x)$ in the following three cases:

1. The expected value of $u_r = s_r - t_r > 0$ (i.e.) $E(u) > 0$. (i.e.) The service operation time is generally greater than the interval between the arrivals: over-saturation, hence large queues result and $F(x)$ takes the form shown in Graph 2.



Graph 2.

2. $E(u) > 0$. (i.e.) This case constitutes one of under-saturation and $F(x)$ takes the form shown in Graph 3.



Graph 3.

3. $E(u) = 0$. (i.e.) The case of exact balance, this is of most interest since this would normally be the case in section loading in a factory organisation. With a distribution in s_r the process can

be considered to have a new starting point each time the queue disappears. The following conclusion can be reached. It is certain that some item will not have to wait, but the time for this event to occur may be infinite. The probability that a particular item will have to wait, however, approaches 1 and the mean waiting time approaches infinity.

Let the distribution for the service operation time and arrival periods be Poisson. In other words it is assumed that the probability of an arrival interval exceeding value t is given by $D(t) \sim e^{-At}$ and the mean value is $\frac{1}{A}$
and similarly for the service operation times, the probability of the service operation times exceeding value s is given by $D(s) \sim e^{-Bt}$ and the mean value is $\frac{1}{B}$

Let ρ the "traffic density" be defined by

$$\rho = \frac{A}{B}$$

Kendall [5] has shown that:

$$\frac{E(w)}{E(s)} = \frac{\rho}{S(1-\rho)}\left[\,1 + Var\,(sB)\,\right]$$

where; $E(w)$ is the mean waiting time
$E(s)$ is the mean service time
$Var\ (sB)$ is a measure of the spread of s

As is the general case the following points are found:

1. As the mean arrival rate approaches the mean service rate, $\rho \rightarrow 1$, then $\frac{E(w)}{E(s)} \rightarrow \infty$, or the mean waiting time is many times the mean service time.
2. Infinite queues and waiting times occur if $\rho > 1$

2.3 queueing problems in batch production

These theoretically determined features of operations being performed on items at a service point are extremely important. If the factory organisation shown in Fig. 3 is considered, it may be seen that a very large number of service points exist throughout the whole organisation. Whilst the exact probability function for the distribution of service times and arrival periods cannot be theoretically determined, a random distribution of the Poisson type seems applicable in the case of batch production problems.

This being the case, at all these service points where a section is loaded to capacity over a period of time as in current techniques (i.e.) the service rate = average rate of arrival, the above theory shows there is a large probability that queues will exist. There is also a probability that the service points will not be called upon to provide a service at a given time. For example, the problems of overloading or waiting time in a machine shop section involved in batch production processes.

It also shows that current scheduling techniques of under-loading sections in proportion to past experience of hazards will not prevent load bottlenecks (i.e.) the probability of large queues developing still exists.

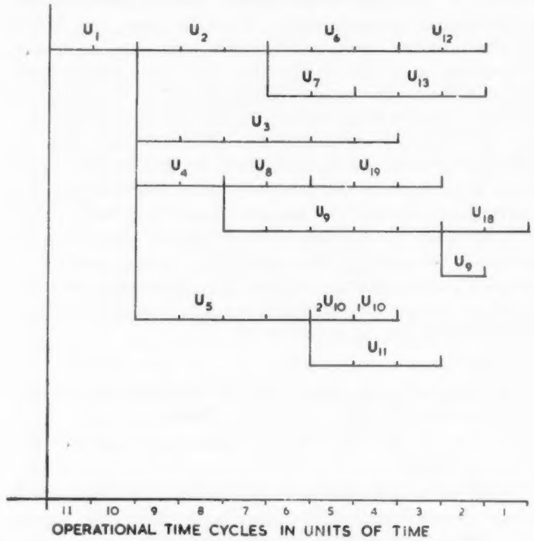


Fig. 4. (See Section 3.1.)

The writer considers the solution to the problem may be obtained by:

1. accepting the fact that there is a probability that queues will exist at all service points within the organisation;
2. the development of "decision functions" which will enable the queue order to be sequenced in a manner resulting in the optimum profit position of the integral organisation.

3.1 scheduling systems

Fig. 4 shows the manufacturing cycle in units of time required to complete the manufacture of U_1. It will be seen that the longest individual manufacturing cycle U_{18}, U_9, U_4, U_1 governs the length of the overall manufacturing cycle of U_1. The question may be asked: "How are the individual time cycles ascertained ?". One method is to allocate a period of time per operation, irrespective of the actual operation. Justification of this method compared to that utilising estimated times for each operation cannot be made here. Experience has shown, however, that good correlation can be made to exist between the number of operations in the longest individual cycle and the time required for the overall manufacturing cycle, if the following rules are observed:

1. Job-splitting techniques are utilised when any individual operation has an estimated time greater than half the total time period allocated per operation.
2. The transit time between sections is maintained within the remaining half period (transit time is defined to include the time required to complete any necessary intermediate operations between sections).

Thus the overall manufacturing cycle for U_1 is 11 units of time, since the longest individual cycle U_{18}, U_9, U_4, U_1 contains 11 operations, assuming 1 unit of time is allocated to each generalised operation (see Fig. 4).

The master scheduling plan is constructed by superimposing each new order on to the forward factory load. Each operation is assigned a required completion date one unit of time later than its predecessor. Thus referring to Fig. 4 U_{10} requires two operations, ${}_1U_{10}$ and ${}_2U_{10}$, these will have required completion dates 4 and 5 assigned respectively.

As each operation has a required completion date assigned, the section concerned will receive an additional future load. That is the time estimated by the Ratefixing section to complete the particular operation in question. The problem will arise when the addition of a further load to a section at a specified time will result in the overloading of that section. This problem will be resolved by the Production Control centre by either sub-contracting or revising the planned delivery date to accommodate the given operation at a time when the section in question is not overloaded.

In theory this system should be adequate to enable predicted delivery dates to be maintained. However, as Part 2 has shown, the features of a batch production system are such that probabilities exist that load bottlenecks will occur at any service point in the system. Thus an individual item may be held waiting in a queue at a service point, its actual completion date thus falling considerably behind that required by the master schedule. Unless expediting action is taken the completion of the final assembly must be delayed.

Since operations for items required for many different orders may be held in a queue in an individual section, the proper arrangement of this queue is of prime importance. The following section, the development of decision functions, describes functions enabling queue sequencing to be controlled.

3.2 development of decision functions

To illustrate the principle involved in the use of decision functions, consider the following function:

$$\varphi = \frac{(\alpha - A)}{(\tau - T)}$$

where:
- φ is a decision function
- T is date unit is required for despatch
- τ is date order received by integral organisation
- α is actual date
- A is required completion date on action document for operation concerned

With reference to Fig. 4:

if α for ${}_2U_{10}$ was 7 then $\varphi = -\cdot 2$ (i.e.) ahead of schedule

if α for ${}_2U_{10}$ was 5 then $\varphi = 0$ (i.e.) on schedule

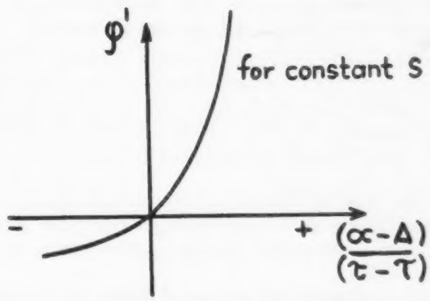
if α for ${}_2U_{10}$ was 3 then $\varphi = +\cdot 2$ (i.e.) behind schedule

Note in the above example the values of the parameters τ and T are taken as the in and out dates for the manufacturing cycle for simplicity. Thus if the value of φ was calculated for a series of items in a queue at a section at a given time the queue could be sequenced according to the value of φ. It must be stressed that the above function is not the optimum decision function. The form of the optimum decision function would be a highly complex task to compute.

It has been argued that the decision functions should as far as possible reflect the cost of delayed delivery. There are difficulties here since it is often difficult to estimate the market repercussion of late delivery. A more sophisticated function is shown below:

$$\varphi^1 = S \left(e^{\frac{(\alpha - A)}{(\tau - T)}} - 1 \right)$$

where S is the selling price of the unit concerned. This function is shown in graphical form below in Graph 4.



Graph 4.

Here the value of φ^1 increases rapidly for increasing delay periods.

It would seem probable that the values assigned to the parameters in the optimum decision function would vary for different orders. The problem of computing the form and parameters of the optimum decision function would be essentially that of the operations research type. It would in the writer's opinion be solved not by analytical methods, but by simulation using the Monte Carlo method using an electronic computer [6].

4.1 some problems of information feedback in factory control

The characteristics of management responsibility for control may be defined as the measurement, appraisal and direction of the activities of those in the organisation. In the past the above-mentioned appraisal has too often been based on insufficient information, intuition, past experience, supposition and post mortem reports. The many parameters which must be considered before management decisions may be taken can rarely be measured simultaneously under

existing systems of information feedback. The reason for this is that current information feedback channels invariably involve data processing at several service points in series. These are all subject to probabilities that queues of data will form, with the consequent delays in processing. Thus the management are often presented with incomplete and obsolescent information.

At this stage a brief consideration of a fundamental principle of cybernetics is instructive. Cybernetics [7] has been defined by George as the general name for the study of all control and communication systems. A salient feature of cybernetics is the idea of control being primarily a process of negative feedback. The negative feedback notion of "error actuation" is important, since the writer considers its application to factory control systems can result in a reduction in the volume of data processing required.

The writer considers the use of decision functions described in 3.3 would enable a system of control by "error actuation" to be implemented, which would result in a number of advantages over existing methods of overall factory control.

4.2 suggested methods for implementing control by decision function techniques

The implementation of a system utilising decision function techniques must obviously vary according to the types of batch products the integral organisation is engaged in. The writer envisages a possible system with features summarised below:

1. The present concept of production control and scheduling to be extended to cover all service points within the integral organisation where feasible.
2. Scheduling techniques to be developed to enable service at all service points to be planned.
3. Action documents to be developed to facilitate sub-paragraph 2 above.
4. Optimum decision functions to be developed and the parameters involved to be evaluated for different types of orders.
5. The addition of electronic typewriter stations at all service points, enabling the rapid transmission of all relevant information required for queue sequencing to a factory control centre, for the evaluation and return of decision function values to the service points.
6. The use of a medium-sized general purpose computer suitably programmed to enable

   (a) the evaluation of decision functions on all orders;

   (b) the memorising of overdue item's action document identification in two classifications, namely:

      (i) Order classification

      (ii) Section classification.

Thus control would exist at all service points in the generic organisation shown in Fig. 2, from the unit breakdown section to despatch. The electronic typewriter stations would only transmit queueing item's action document information to the control centre at specific intervals of time. This information would be then analysed as described in sub-paragraph 6 above and returned to the service points concerned. The sections would then sequence the items according to their decision function value and complete the necessary service.

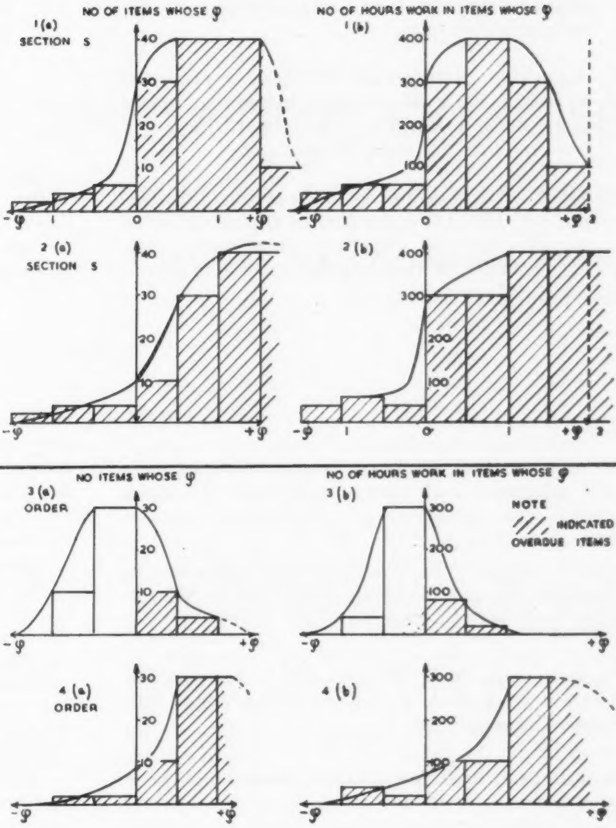
4.3 advantages of control by decision function technique

Apart from the use of decision functions to enable queue sequencing to be carried out as described in 4.2, other important data may be readily analysed. If a statistical distribution of the decision function values for the number of overdue items on a specific section were to be constructed, section loading characteristics could be obtained as shown hypothetically in the histograms 1 - 4. It must be noted that overall loading characteristics cannot be obtained by the "error actuation" principle but are based on the decision function values for all the items on a section at a specific time. The overall loading characteristics are shown in histogram form and are described below:

1. The histograms 1(a) and 1(b) show hypothetical loading characteristics of a section S_n which has an assumed capacity of 1,000 hours per operation time period. The control of items supplied to the section is near optimum, since in a unit operation time period virtually all the hours contained within the asymptote $\varphi = 2$ (note $\varphi = +2$ assumed $\equiv$ unit operation time period) will be completed. Under these conditions section throughput will be rapid.
2. The histograms 2(a) and 2(b) show section S_n overloaded. The number of hours overdue is in excess of the section capacity and a load bottleneck is predicted, thus enabling expediting action to be taken at an early stage if considered necessary in view of future section loading, with the result that section throughput may be maintained reasonably constant.

A second important use to which decision function techniques may be applied is that of the appraisal of an individual order position. If all overdue items on an order are analysed as in sub-paragraph 6(i), further hypothetical histograms, as shown, could be obtained and are described below:

1. The histograms 3(a) and 3(b) illustrate the position of an order showing satisfactory progress compared to the master schedule. In this instance few items are overdue and no special action would be necessary, since these items would be automatically brought to the front or near to the front of the queue in the sections they passed through.



Histograms 1-4 (see Section 4.3).

2. The histograms 4(a) and 4(b) show an overdue order. In this instance the very large number of items and hours overdue could only be resolved by modifying the values of certain parameters in the decision function for the order concerned in the computer memory, to either revise the delivery date or establish a definite "right of way" for overdue items.

The above concepts are obviously embryonic in nature, but provide an indication of the possible sophisticated form of controls made available by the use of decision function techniques.

5. conclusion

The problems of factory control in a batch production organisation are extremely complex and the profit position of the organisation must be significantly influenced by their correct solution. The source of many factory control problems has been shown to be that of service at a service point where the rate of arrivals and the service times are subject to a random distribution. It has been shown that where the rate of arrival equals the mean service time, there is a definite probability that large queues will form and load bottlenecks will result at these service points.

Since all sections and information feedback channels within the integral organisation may be regarded as service points, this results in extremely complex multi-stage queueing problems, which cannot be solved theoretically. It would appear that control at all service points is essential and that this control should enable the overall profit position of the company to be optimised.

The writer is convinced that the urgent requirement for dynamic overall scheduling cannot be resolved by any forms of automatic data processing alone, but that control techniques must be developed analogous to control by negative feedback in electronics. Thus control by "error actuation" is required enabling queues to be sequenced to minimise the overall cost of delayed delivery.

The form of "error actuation" control envisaged by the writer is that utilising decision functions in conjunction with rapid feedback of information to a computer control centre by electronic transmitting stations. The advantages of such a system are considered to be:

1. Order position may be accurately summarised at specific intervals enabling expediting action to be taken either to bring overdue items forward or to revise the delivery date by modifying the

requisite decision function parameters in the computer's memory.

2. Accurate section forward load may be predicted at specific intervals enabling expediting action to be taken to maintain the forward load at a level required for rapid throughput.

3. Special orders requiring rapid factory throughput may be easily controlled by the allocation of suitable decision function parameters. The responsibility for deciding the acceptable overall loss of profit by such action must lie with the management.

4. Decision function techniques may probably be developed further to enable future factory loading to be more accurately predicted.

The Paper deals with only one aspect of factory control but illustrates the research approach the writer considers necessary before any major advances in resolving problems of factory control may be envisaged.

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BUSINESS SIMULATION EXERCISES

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WAR Games and Army "Dry" exercises are well established as a means of training in the armed services. By simulating particular conditions it is possible to test the effects of competing strategies in model form rather than in an actual situation.

Not only has this proved of considerable value in training officers in military strategy, in decision making and in the evaluation of their decisions, but the technique of simulation has served as a basis for the development of new strategies where such basic elements as new armaments have become available. Some similarity exists between the active military and business situations: each organisation has specific objectives to attain at a required level of achievement with a minimum cost.

Under changing conditions of business competition, various strategies are employed in relation to particular company policies and decisions with regard to achieving the objectives must be made. The situations are dynamic and, in their entirety, may well be complex. It is also recognised that the effect of the decisions of competing companies on the achievements of an individual competing company is of an interacting nature.

To assist in the training of management personnel the principle of the "dry" exercise has been adopted for business situations, with the result that over the last three years several Business Games or Business Simulation Exercises have been developed. Prominent among the designers and users of the exercises are:

The American Management Association
International Business Machines Ltd.
General Electric Company, U.S.A.
McKinsey & Co., U.S A., Consultants
American Telephone & Telegraph Co.
University of California, Los Angeles
Carnegie Institute of Technology
Shell Mex and British Petroleum Ltd., Great Britain
The National Coal Board

The exercises are based on the simulation of conditions of varying degrees of complexity and the construction of mathematical models representing dynamic business situations.

The competitive element is maintained by arranging for the training group to be divided into smaller groups representing rival companies or by members competing on an individual basis; the nature of the exercise indicates which of these arrangements is more suitable. In order that the dynamic nature of business may be taken into account, the participants are required to make decisions at regular periods of time in the light of changing conditions. After each set of decisions has been made their effect is assessed. Information is provided of each group's activities and results so that plans and decisions may be made for the subsequent period. Since decisions must be made within a limited time in real life, the periods set aside for decision making are limited in time also. In this way long business periods may be compressed, in terms of results, into a matter of hours or days, depending on the depth of the exercise.

types of exercise

There are two main classifications: the games may be "interacting" or "non-interacting".

In the former the decisions and achievement of one group will affect the achievement of other groups. In the latter case, the results of decisions are based solely on the work of the group making the decisions.

Games may also be classified as "Functional" or "Total Enterprise". Functional games deal specifically with organisation functions in isolation and may cover such matters as production programme or stock control. "Total Enterprise" games involve participants in making decisions in terms of a company as a whole; such decisions relate to product selling price and expenditure allocations which may provide for the expansion or contraction of production, sales, research and other facilities.

The following examples illustrate the general approach in business simulation exercises from the quick functional type to the more complex total enterprise game in non-computerised or computerised forms. The details given are in broad outline only so that the value to future participants and training bodies is not destroyed. Those responsible for devising the game are mentioned in brackets after each title.

Production Programming Exercise
(General Electric Co., Inc.)

This exercise is of the non-interacting functional type which may be conducted on an individual basis, and illustrates the way in which an exercise can be designed to improve efficiency in using a particular technique. Participants are required to programme manufacture so that the overall unit cost of production is at a minimum.

A sales forecast for the year to be planned is available, but it is recognised that individual month's sales have varied by as much as 30% - 35%. The planner must programme manufacture with a policy of producing at a sales level such that inventory carrying charges will be kept at a minimum.

Information is available of direct labour hours per unit, labour pay rates for normal shift, overtime and night-shift working, output capacities and inventory carrying cost. The planner takes over finished stock at the end of December, forecasts requirements for January and further ahead on a tentative basis. A specific level of stock is required at the end of the year for which programming will take place. When the planner has made firm decisions for January he is told the actual sales for the month. Monthly forecasting, firm planning and actual sales follow consecutively throughout the year.

Finally, the costs of carrying inventory, of increasing and decreasing production and of labour are computed on an annual basis and participants' results compared. It is not unusual to find cost differences between participants of 100% or more; the significance of such a wide variance in cost and scheduling efficiency is clearly apparent. All planners start with the same conditions, yet may finish with widely different efficiencies and discover the reasons for themselves.

Materials Inventory Management Exercise
(Green & Sisson)

An alternative ordering policy based on Economic Batch Quantity calculation is illustrated by this exercise.

The procedure is somewhat similar to the previous example and participants are able to compare cost analyses of results from scheduling on a "common sense" basis with a schedule based on an Economic Batch Quantity calculation with the Sales trend assessed from a three-week moving average.

Personnel Assignment Exercise
(Green & Sisson)

This exercise sets out to allow the participant to compare the results of his initial allocation of manpower with the results obtained from a subsequent understanding and use of linear programming. Thus an operational research technique to solve the problem of minimising costs and maximising profits is illustrated and the exercise is a further demonstration of the way in which interest in a specialist technique can be aroused and its advantages discovered.

Marketing Strategy
(McKinsey & Co. Inc.)

A contrasting form of exercise has been developed by McKinsey and Co., as part of their consultant staff training programme.

Three small groups are formed, representing three competitive well-established companies, and each group plays the role of a company top level decision making team. Each company is considered to have developed manufacturing facilities for the production of a similar new product. The product is specified, together with information with regard to the sales practice of each company. Market research information is provided and the average amount that each company may reasonably expect to spend on total marketing effort is stated. Teams must consider matters of product price structure, the effect of the new product on the sales of the present main product, the forward planning of manufacturing capacity, the means of advertising (for which costs of the various media are given), field sales effort, further market research, future product development and other related matters. Firm market strategies for each company must be developed for the first year, and each group chairman presents a report on his company's decisions to all participants.

With the knowledge of other companies' first year decisions, each group must then re-examine its policies and establish firm strategies for the next four years. Policies for the first year can be changed for the subsequent four-year period.

Groups are again brought together for the presentation of the four-year strategy decisions. A representative from each team appraises the strategy of competitors and a further representative defends his own company strategies.

The exercise provides an example of a business game which has no positive winner and is less dynamic in nature. Judgment is based on the critical appraisal of the persons conducting the game; where these are experts in the particular field, the exercise serves as a useful basis for training in the consideration of decision effects.

Business Management Game
(McKinsey & Co. Inc.)

The first version of this exercise was developed by G. R. Andlinger and J. A. Greene and is described fully in the Harvard Business Review March - April, 1958. It is probably more widely used than any other total enterprise game. The effect of team decisions is determined partly by statistical probability. In this regard random number tables are used, by the assessors only, with cut-off points determined by specific probability levels. Probability levels change depending on investment and other matters; rules for decisions on such points are built into the structure of the exercise, which is run without the use of a computer.

The structure of the management exercise is such that two or three teams, representing the management

Corporation C *Quarter* 10 *Year* 3

Location of Salesmen		*Actual Sales*
1	... 2	2
2	... (2)	—
3	... —	—
4	... (1)	1
5	... 1	—
6	... —	—
7	... 7	—
8	... —	—
9	... 10	2
10	... —	—
11	... 8	2
12	... —	—
13	... 3	1
14	... —	—
15	... 9	—
16	... —	—
17	... 4	2
18	... —	—
19	... 5	—
20	... —	—
21	... —	—
22	... 6	3
23	... (6)	1
24	... —	—

Total sales 14

ASSETS

	£
Cash	2,000
Accounts receivable	100,000
Inventory-finished goods	18,000
Work in Process	84,000
Plant	180,000
Total assets	£384,000

NEW WORK IN PROGRESS

Fixed cost	15,000
Variable cost (*10*)	30,000
Total work in process	£45,000

CASH

	£	£
Beginning cash		2,000
Accounts, receipts, collections ...		100,000
Total income		102,000
Total expenses	32,000	
Work in process cost ...	45,000	
Plant investment ...	—	
Total outgo		77,000
Ending cash balance		£25,000

PROFIT AND LOSS STATEMENT

SALES AND INVENTORY	*Units*	£ *Value*	£ *Sales*	£ *Value*
Beginning inventory	4	18,000		140,000
Production	10	45,000		
Total inventory	14	63,000	63,000	
Less units sold	14		63,000	
Ending inventory	NIL		NIL	63,000
	£			
GROSS MARGIN				77,000
Hiring expense	—			
Salaries	20,000			
Advertising	12,000			
Research and development	—			
Factoring expense ...	—			
Staff work	—			
Total expense	£32,000			32,000
NET PROFIT				£45,000

NOTE — one page advertising required in each region.

Fig. 1.

personnel of one-product capital goods companies, compete for a common market. In effect, each management is responsible for the overall running of a company from the state of initial building of plant to the end of a trading period of several years.

After an initial briefing, and possibly a short trial run, decisions are made for a quarterly period. The accompanying Decision Form and Profit and Loss Statement (Fig. 1) indicates the main elements involved. Assessors compare the decisions of each company, allocate sales if any have been made, complete the Profit and Loss Statement and return a copy of the statement to the appropriate team. On the basis of his information decisions are made for the subsequent quarter.

Team decision periods are normally in the order of 20 minutes, decreasing as the exercise progresses to 15 minutes. Very careful planning is necessary to ensure effective umpiring so that each assessment is not only accurate, but is completed within an equally short time.

Methods of working, presenting, comparing and finally assessing results are similar to the following game.

Management Decision Making Laboratory. Model 1 *(International Business Machines Ltd.)*

This interesting exercise, originally developed for their own executive training programme, has been made available to industry generally by IBM Limited and is a further example of a "total enterprise" interacting decision game.

Here a mathematical model of a business economy has been constructed, and programmed for a computer, within which three companies produce and sell the same product in competition with each other. Small groups are formed; different members of each group assume the responsibility of advising on particular aspects of each company's business — for example, Finance, Marketing, Research and Development, Production and Plant.

Each company starts on the same basis, with a good trading potential but a financial position which is far from healthy. The objective is to put the company into a good financial position, but final judgment in deciding on the most successful company is based not only on profits and total assets at the end of the exercise, but on long term operation plans as well.

Each company has a different geographical home area, in which its factory and administrative offices are established, and thus has a transportation advantage in its own territory. A fourth area has no company and offers equal competition to each of the three firms.

Decisions for each quarter-year's company operations are made at 30-minute intervals reducing the periods to 15 minutes, and entered on special forms. The information is transmitted to an electric computer installation where it is translated on to punched cards and fed into an IBM 650 computer. The computer calculates the results of the period's trading and a summary is listed (Fig. 2) for each member of each company by a printing machine. The complex data processing takes only a matter of minutes, so that the effects of four or five years' operations can be compressed into two days. Teams must make decisions in terms of expenditure on production, marketing, transportation, research and development in relation to their ability to meet their financial commitments.

Selling prices may be varied in the different sales areas and, within limits, increased marketing expenditure can increase the demand for the product. Investment in increasing production efficiency can reduce the unit cost of production. Extra plant may be installed and manufacturing capacity increased, but if plant utilisation is low due to lack of orders the unit cost of production increases. Inventory may be carried to meet future orders, but the cost of investment will not be recovered until sales are completed.

These are just a few of the matters in which decisions must be made. Teams must make decisions on general policy and also on specific items to achieve their objectives. But one of the most valuable conclusions at which participants arrive is that no aspect of company planning can be considered in isolation.

Management decision-making laboratory IBM

Model I

Company 3 Period 1 Date

		Area 1	Area 2	Area 3	Area 4
Company 1	Price	4000	40 00	40 00	40 00
New price					
New marketing expenditure					
Expected sales (units)					
Company 2	Price	40 00	40 00	40 00	40 00
New price					
New marketing expenditure					
Expected sales (units)					
Company 3	Price	40 00	40 00	40 00	40 00
New price					
New marketing expenditure					
Expected sales (units)					

Sales income	Assets	Current	Change	
Total sales	Cash	9841		%
	Inventory	1023		%
Net income	Plant	5200		%
	Total	16064		%
Total sales	Cash	9841		%
	Inventory	1023		%
Net income	Plant	5200		%
	Total	16064		%
Total sales	Cash	9841		%
9640	Inventory	1023		%
Net income	Plant	5200		%
114	Total	16064		%

	Area 1	Area 2	Area 3	Area 4	Total	Change in percent
Orders received (units)	141	141	141	300	723	%
Sales (units)	141	141	141	300	723	%
Marketing expenditure	350	350	350	750	180 0	%

	Area 1	Area 2	Area 3	Area 4	Total
Orders received (units)	20	20	101	100	241
Sales (units)	20	20	101	100	241
Marketing expenditure	50	50	250	250	600
Sales income	800	800	4040	4000	9640
Delivered unit cost	36 97	36·97	34·97	35·97	—

	Last quarter			Next quarter	
	10% less	Actual	10% less	Plant capacity	Inventory
Quantity	211	234	257	260	29
Unit cost	36·20	35 26	34 53	34 44	35·26
Total cost	7638	825[illegible]	88 74	8954	1023

Sales income	9640
Cost of goods sold	8428
Transportation	180
Marketing	600
Research and development	100
Depreciation	104
Income before taxes	228
Taxes	114
Net income	114

	Production
	Transportation
	Marketing
	Research and development
	Plant investment
	Total
9841	Cash available

Fig. 2.

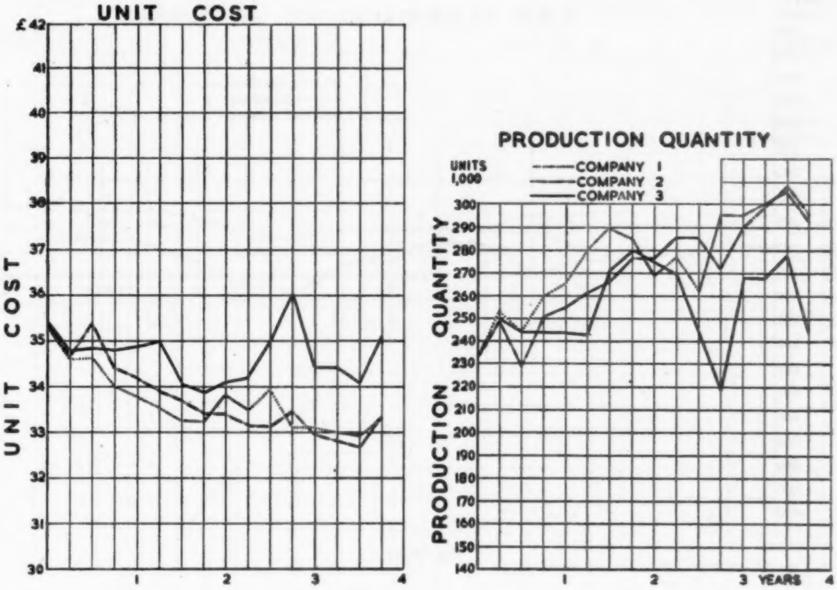


Fig. 3(a).

If teams are to determine trends and check their position from time to time records and graphs must be kept so that a full appreciation of a situation may be gained and decisions made accordingly.

Not least in importance is the critique session at the end of the business venture. A complete graphical analysis of the long trading period covered provides a visual comparison of trading results. Company chairmen then state their policies, decisions and reasons for their actions. Successes, failure and hopes for the future are examined and, it is hoped, a broader and valuable view obtained of the top level decisions involved in running a manufacturing company.

possible limitations of business exercises

For purposes of playing time the results of some decisions may be achieved earlier than may well be the case in practice — for example, company expansion by the purchase and installation of new plant. An exercise may also lose some of its reality by some simplification of what could be extremely complex conditions.

Participants are sometimes disturbed at an apparent ability, on the part of an exercise designer, to specify the cost of running out of stock. Indeed, this is a problem which frequently confronts operational researchers and which they are unable to quantify precisely. But the originator of the exercise has simply emphasised that a cost must be recognised and has inserted a penalty accordingly.

It is possible that wrong conclusions may be drawn. For example, a profit may be made by an unrealistic curtailing of expenditure on such items as Sales, Service, Research and Development. A game may be won by making such decisions just before the end of the exercise. However, originators establish standards of good practice so that such subterfuges may be taken into account by the assessors.

Points such as these emphasise the need for company organisers of such games, or lecturers, to stress possible differences from reality and to draw attention, particularly in the critique session, to lessons which may be learned from the actual decisions made, within the limits of the economic structure which has been simulated.

It is most improbable that general exercises of any magnitude will reflect individual company practices. However, such a criticism would be far from fair since it was never intended that they should. Rather, where such an advantage is required, it emphasises the need for a company to simulate its own conditions and, indeed, operational researchers are tending to do this as a by-product of their normal investigations.

a recent course on Business Simulation Exercises

A special course, of one week's duration, was held recently at the University of Birmingham, Institute for Engineering Production, within its series of residential executive courses.

The course was arranged in co-operation with Professor Franklin G. Moore, of the University of Michigan, who has extensive experience of the application of a wide variety of such exercises.

Course members, from widely different industries, examined and participated in a variety of games from the simpler to the more sophisticated types. The

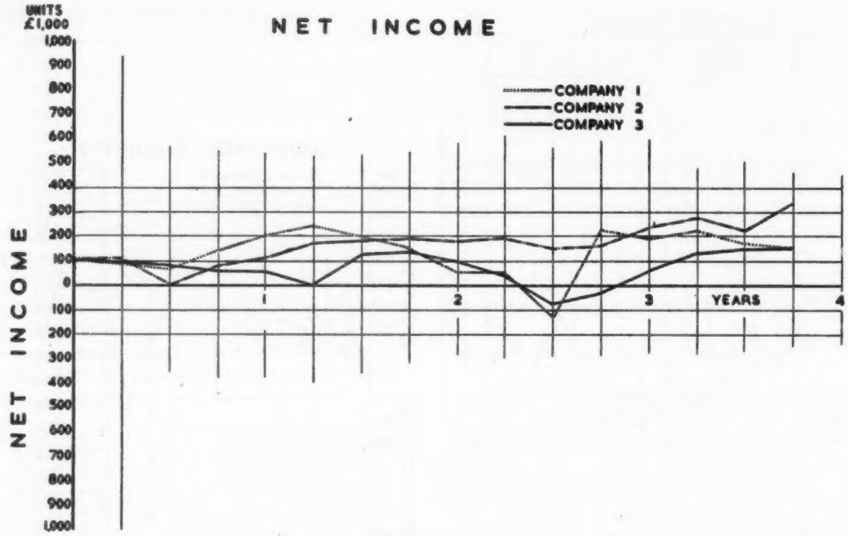


Fig. 3(b).

IBM computerised exercise was played and the charts in Fig. 3 show the graphical analysis of the results of three competing groups. Considerable interest was aroused and members were able to gain a valuable insight into this new form of training and examine the advantages of introducing or extending the use of business games in their companies.

Experience by other education bodies (for example Sundridge Park Management Centre), where course members have taken part in repeat sessions of exercises, has shown that the ability of participants to make decisions has improved.

the significance to the production engineer

Production engineers are aware of the necessity of reconciling specialist requirements within a company so that overall objectives can be attained. But decisions with regard to such compromises only become the responsibility of the production engineer when he assumes very senior executive authority. Preparation for making decisions based on an overall rather than a specialist view is vital, therefore, if the engineer is to pass from a purely specialist to a wider administrative function. The use of business simulation exercises in this regard is not an attempt to underestimate the importance of experience gained

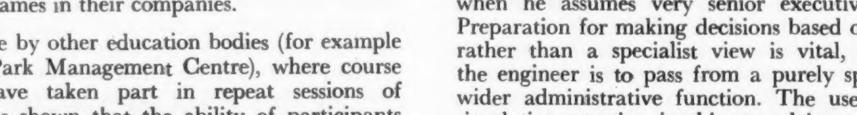
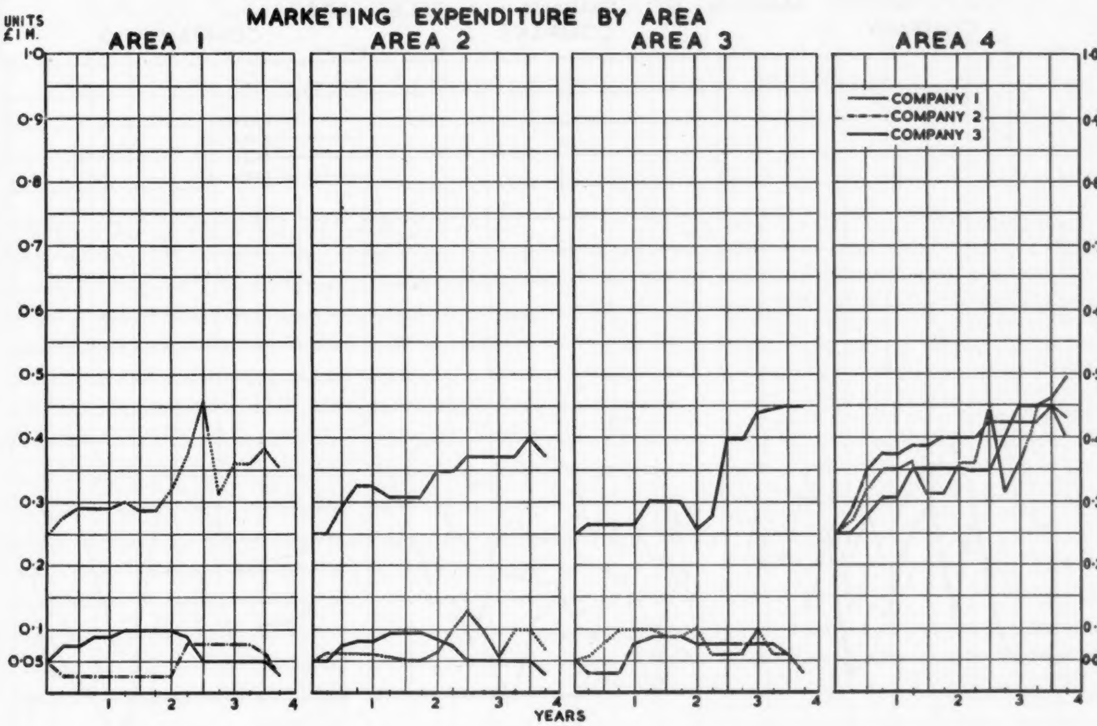
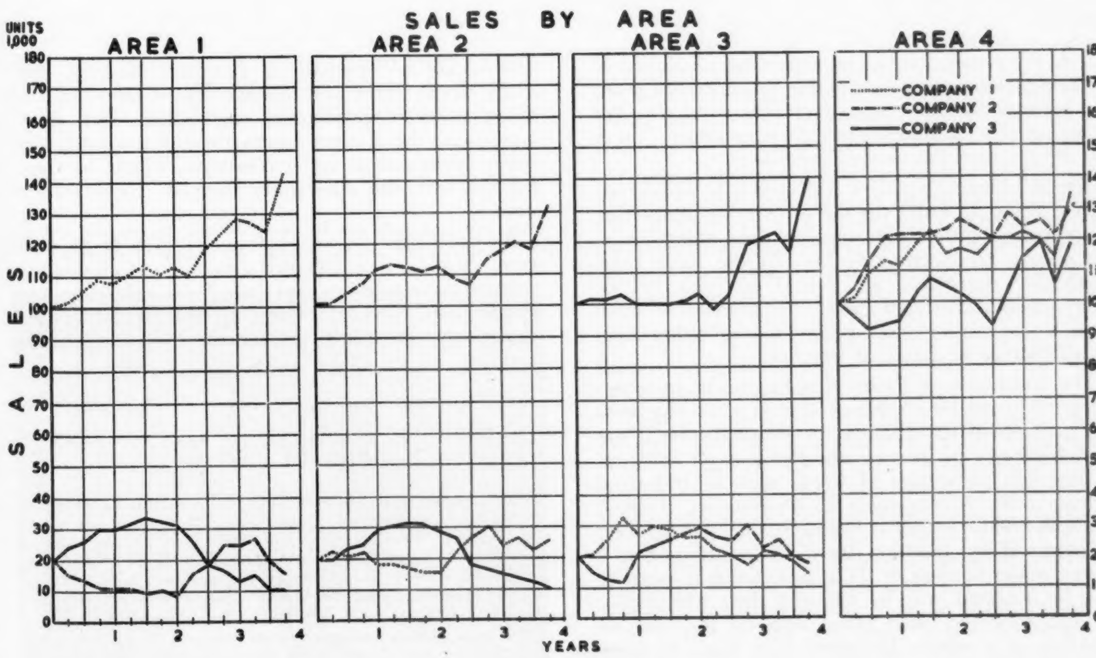


Fig. 3(c).



MARKETING EXPENDITURE BY AREA
UNITS £1 M.
AREA 1
AREA 2
AREA 3
AREA 4
COMPANY 1
COMPANY 2
COMPANY 3
YEARS

Fig. 3(d).



SALES BY AREA
UNITS 1,000
AREA 1
AREA 2
AREA 3
AREA 4
SALES
COMPANY 1
COMPANY 2
COMPANY 3
YEARS

Fig. 3(e).

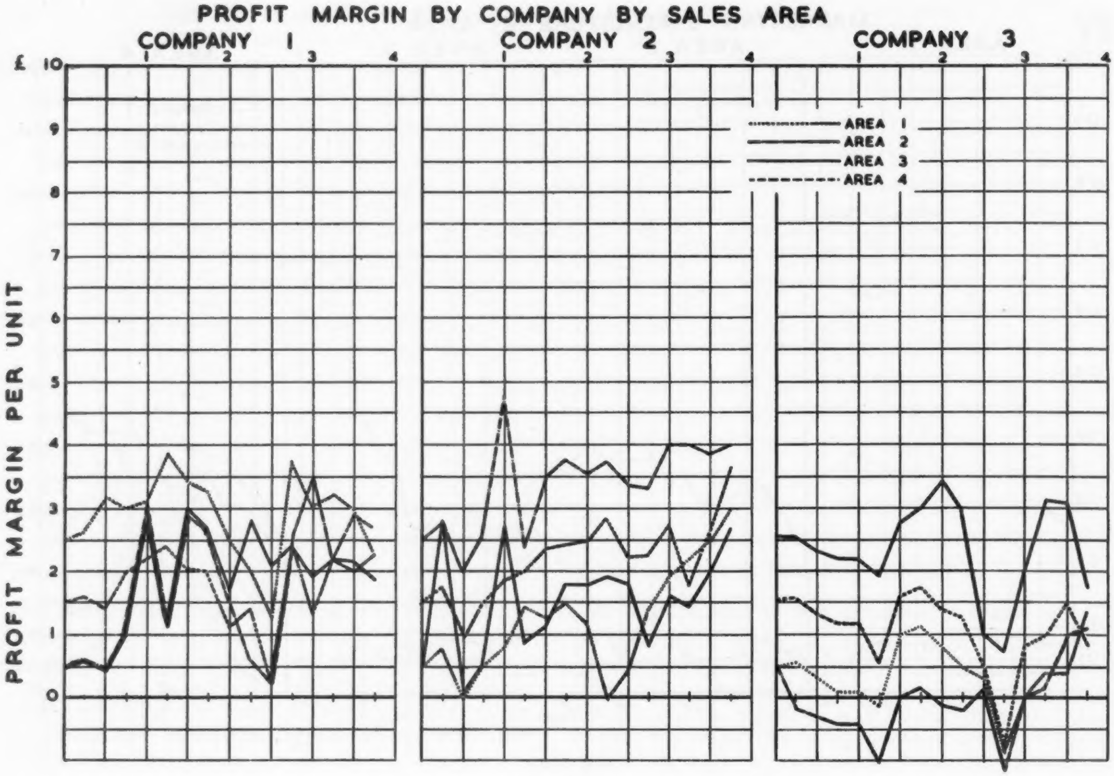


Fig. 3(f).

by real life responsibility, but rather the acquisition of decision-making experience within preconceived limits and without loss to a manufacturing company. We recognise that training solely "by exposure" in a real life situation can be very expensive.

The production engineer will always be concerned with training his staff; the use of exercises simulating functional conditions can improve their ability in an atmosphere approaching reality. At the same time, responsible executives are forced to appraise the techniques demonstrated and the critical view adopted tends to an improvement of techniques rather than an acceptance of standard practice.

The Institution of Production Engineers, in recognising the broadening horizons of production engineering, has revised its examination requirements; it has been necessary to increase the demand on students. A thorough knowledge of topics such as Industrial Management, Management of Production, Applied Statistics and Operational Research, may perhaps best be obtained by teaching them in isolation. But a proper understanding of their importance in practice may be obtained only by knowing their relationship to, and effect on each other, and on the business situation as a whole. Lecturers take pains to stress such connections and, in these exercises, now have a new means of emphasising inter-relationships, and many other important management factors, in the broad study of production engineering. But, more important, the student learns these relationships by active participation under conditions which, by comparison with the case study method, are far from static.

As time goes on we shall see a growth of such exercises and a more detailed simulation of production engineering conditions and data. Such a development should add further interest to the study of the engineering disciplines on which the Institution is founded.

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(*concluded on page* 408)

SIXTH CONFERENCE OF STANDARDS ENGINEERS

Record Attendance at May Meeting

The Sixth Annual Conference of Standards Engineers, held on 11th May, 1960, at the Connaught Rooms, London, attracted a record attendance of 280 delegates. These included engineers, designers and other technical or administrative experts with a responsibility for the application of standards in a wide variety of industries. This year a welcome was specially extended to a number of overseas visitors and representatives of the technical press.

The Chairman of the Conference, which is organised jointly by the Institution of Production Engineers and the British Standards Institution, was Mr. R. E. Mills, Chairman of the I.Prod.E. Standards Committee.

THE Conference was opened by Mr. Lewis Wright (Past Chairman of the British Productivity Council and Chairman of the T.U.C. Production Committee). Mr. Wright conveyed the cordial good wishes of British trades unionists to standards engineers in the work they were doing and would do in years to come. Standardisation, he said, was still almost virgin soil. Though there were over 3,000 British Standards in use today, most of those present surely felt that more like 30,000 should be in operation if all were to work as well and efficiently as they ought.

In the photograph below, some of the delegates are seen registering before the opening of the Conference.

Daily and even hourly, Mr. Wright continued, it was demonstrable how nonsensical parts of British production could be without standardisation. But it was not only engineering problems that standardisation helped solve, but also those of industrial communications. One of the outstanding defects of industry today was the manner in which so many requirements of it make different languages — from top management to workers on the shop floor. The B.S.I. *Glossary of terms in work study,* for example, had proved very useful, and this was one of the kinds of work that should go on and which deserved encouragement. It had been useful to management, trade union officials and workers.

no standardisation of man

One of the prime things that had to be remembered in the work of standardisation was that though engineers would be thinking of practical engineering problems and such things as variety reduction, man himself could not be standardised. It was necessary to fit the job to the worker and not *vice versa.*

It was appropriate that, as a trade union leader, he should confirm at the present time his support of the B.S.I.'s work, and should also take the opportunity to reiterate that he did indeed support production and efficiency, but he would affirm that human activities were in no way subordinate. Mr. Wright concluded by repeating his good wishes on behalf of the trades unions, and by hoping that the present and future work of the B.S.I. would have every success.

As the culmination of discussions during the past year, a decision was taken by delegates attending the annual Conference of Standards Engineers to bring together in an association those concerned with the application of standards in industry. It was agreed that no separate organisation — as was earlier envisaged — should be set up, but that standards engineers and others with a special interest would be able to become associates, on a personal basis, of the British Standards Institution.

The new proposals, outlined to delegates by the Director of B.S.I., were the result of consideration over the year by the I.Prod.E./B.S.I. Committee in consultation with others. Mr. Binney explained that the new proposals would provide standards practitioners with the forum they so evidently desired, and in which they could meet, hold discussions and exchange views. To the few delegates at the Conference who said they would prefer to have an extension of the U.K. branch of the Standards Engineers' Society (of America) Mr. Binney said that B.S.I. was not itself

advocating the adoption of either proposal but was merely anxious to serve standards engineers in the best way possible in accordance with what appeared to be the strong majority view.

Mr. H. B. Bowden (Standards Engineer, AC-Delco) was warmly supported by many when he said that an associateship scheme seemed the best way of tackling the job, but that as a long-term objective they should have close ties with the Standards Engineers' Society in the interests of international standardisation.

Mr. H. Stafford (Standards Engineer, United Steel Companies Ltd., and Past Chairman, I.Prod.E. Standards Committee) said that standards engineers wanted a U.K. grouping of their own and that the only suitable body to sponsor the work was the B.S.I.

After further discussion, delegates by an overwhelming majority voted in favour of the B.S.I. associateship scheme.

It was also agreed at the Conference that there would be regional activities and that initially a fee of a guinea a year would be charged for registration of those who wished to participate.

An application form was available for those wishing to be associated in this new grouping. (Standards engineers who were not at Conference may obtain copies of this form by writing to: The Joint Secretary I.Prod.E./B.S.I. Committee, British Standards House, 2 Park Street, London, W.1.)

An inaugural meeting of all those expressing a wish to participate in the associateship scheme will be held in London on Friday, 8th July.

ELECTIONS AND TRANSFERS — concluded from facing page

PETERBOROUGH SECTION
As Associate Member
M. A. I. Jacobson.
As Student
D. J. Blythe.
Transfer :
From Graduate to Associate Member
E. Kent.

PRESTON SECTION
As Associate Member
J. J. Francis.
As Graduate
E. Hunter.
As Students
A. K. Bird; D. Norris; H. B. Bloor; M. Norris; R. C. Watson.
Transfers :
From Associate Member to Member
W. R. Thompson.
From Graduate to Associate Member
J. Shorrock.

READING SECTION
As Members
G. A. Hunt; J. Hann.
Transfers :
From Associate Member to Member
S. R. J. Goddard.
From Student to Graduate
J. Gifford.

ROCHESTER SECTION
As Graduate
K. W. Simpson.
As Students
A. W. J. Henderson; G. T. Wilson; K. E. Bowles.
Transfers :
From Graduates to Associate Members
D. J. King; E. F. Free.

SHEFFIELD SECTION
As Associate Member
J. Berryman.
Transfers :
From Associate Members to Members
C. Sargent; H. W. Brayshaw.
From Graduate to Associate Member
P. W. Wells.

SHREWSBURY SECTION
As Member
J. R. Martin.
As Students
G. A. Cowdroy; D. R. J. Gosling.
Transfer :
From Associate Member to Member
R. Norton.

SOUTH AFRICA SECTION
As Graduate
H. W. Van Hooff.
As Students
P. C. Kruger; L R. Tyler.
Transfer :
From Student to Graduate
B. J. Youngworth.

SOUTH ESSEX SECTION
As Associate Members
J. C. Searle; F. H. C. Stroud.
As Graduate
R. F. Savidge.
As Students
F. B. James; M. A. Weinberg.
Transfers :
From Associate Members to Members
T. H. Ward; S. A. Clodd.
From Graduates to Associate Members
R. Charlton; A. L. Foster; P. Hayward; R. A. Malivoire; N. M. Powell.
From Student to Graduate
A. T. Humphrey.

SOUTHAMPTON SECTION
As Graduates
P. F. Schluter; J. M. Mossom; V. P. Moores.
As Student
R. G. Bishop.
Transfers :
From Associate Member to Member
S. G. Statham.
From Graduate to Associate Member
N. G. Badley.

STOKE-ON-TRENT SECTION
As Associate Member
H. Johnson.
Transfers :
From Associate Members to Members
R. Pagett; T. Proctor.

SWANSEA SECTION
As Associate Members
G. Gronow; E. B. Moore.
As Graduates
D. B. Ennis.
Transfer :
From Student to Graduate
J. C. Challenger.

SYDNEY SECTION
As Graduate
J. E. Thomson; K. A. Stallard.
As Students
I. B. Roach; R. H. Munro.
Transfers :
From Graduates to Associate Members
D. C. Crooks, C. J. Brookes.

TEES-SIDE SECTION
As Graduates
K. Robertshaw; A. Wilson.
As Students
J. Barr; T. P. B. Johnstone; A. Veitch; S. Lobb.
Transfers :
From Associate Members to Members
E. Cowell; G. W. Brodie; T. J. Scudder.

WESTERN SECTION
As Associate Member
C. E. S. Burgess.
As Students
J. A. Hulin; D. Pickering; C. E. Feltham; M. W. N. Morrell; K. D. Breakwell; M. C. Skinner.
Transfers :
From Associate Member to Member
D. G. Scott-Maxwell.
From Graduate to Associate Member
D. G. Iles.

WOLVERHAMPTON SECTION
As Associate Member
G. F. Gilmore.
As Graduates
J. E. Whittle; A. K. Mitra; I. Gailas; J. R. Griffiths; T. L. Bartlett.
As Students
M. D. Moore; K. J. Lloyd; P. N. Carter; N. Chakrabarty; P. Westwood.
Transfers :
From Associate Member to Member
G. T. Price.
From Graduate to Associate Member
F. W. Slater.

WORCESTER SECTION
As Associate Member
G. H. Hopkins.
As Students
B. Lockyear; J. B. Carmichael.

NO SECTION
As Member
E. R. Adams.
As Associate Member
N. A. Hawa.
As Students
J. P. Jangra; P. J F. Spedding; H. S. Wah; K. M. Chan; K. P. Chen; K. C. Kwong; C. H. Kong; C. K. Lai; L. M. Kun-San; Y. K. Lao; K. C. Paau; T. F. Chwang.
Transfers :
From Associate Member to Member
G. A. P. Waplington.
From Graduates to Associate Members
F. P. Wallace; L. Wix; M S. U. D. Khan.

ELECTIONS AND TRANSFERS

28th April, 1960.

BIRMINGHAM SECTION
As Members
W. H. Davies; S. A. Tobias.
As Associate Member
H. J. Hemmings.
As Associate
D. T. Nicholls.
As Graduates
C. Kendrick; B. A. Picken; S. C. Ludgate; W. Turnbull; G. Brown; J. B. Allen; B. W. Grigg; V. G. Haynes; J. Domone; A. R. Guy; D. W. Aston; S. H. Watson.
As Students
B. A. Osborne; E. W. Pyke; P. Deakin; M. L. Perry; W. H. P. McWhirter.
Transfers :
From Associate Members to Members
J. R. Brooks; V E. Shute; G. H. Crump; F. E. Rattlidge; R. D. Preece.
From Graduates to Associate Members
R. J. Clarke; G. W. Jackson; E. L. J. Thorne.
From Students to Graduates
J. T. Wilkinson; M. R. L. Daniel; J. S. Detheridge.

BOMBAY SECTION
As Associate Members
E. M. N. Manekshaw, S. C. Roy.
As Students
P. S. Manickam; B. R. Dinesh; N. K. Bhaduri; M. U. Kuriakose.
Affiliated Firm
The Indian Tool Manufacturers Ltd.

CALCUTTA SECTION
As Student
S. Sarkar.
Transfer :
From Associate Member to Member
J. W. L. Russell.

CANADA SECTION
Transfers :
From Graduates to Associate Members
B. Mansell; D. A. King.
From Graduate to Associate
J. M. H. Heines.
From Student to Graduate
A. C. Middleton.

CARDIFF SECTION
As Associate Members
W. Jones; A. M. Davis.
As Graduates
J. G. Beese; T. L. Quick
As Students
G. Roberts; G. Evans; G. C. Hitchings; C. Spratling.
Transfers :
From Associate Member to Member
A. E. Dodson.
From Graduates to Associate Members
D. J. Tantrum; P. I. Collier.
From Student to Graduate
D. A. T. Long.

COVENTRY SECTION
As Member
F. Bailey.
As Associate Member
G. H. C. Rhodes.
As Associate
V. F. Roberts.
As Graduates
L. S. Clarke; K. S. Wilson; C. A. Walters; A. Cordiner.
As Students
R. C. Turner; A. Dennis; R. A. Veryard; A. N. Clark; J. A. Wood; B. O'Neill; B. J. Tuck; D. B. Davies; R. L. Scowen; J. C. Dickinson; B. P. Woodroffe; D. A. Harrison; W. R. Gregory; M. J. Halligan; C. Tipson.

DERBY SECTION
Transfers :
From Associate Member to Member
N. C. Hallsworth.
From Student to Graduate
J. A Moore.

EDINBURGH SECTION
As Graduate
I. E. Henson.

GLASGOW SECTION
As Associate Members
D. F. Irving; E. McL. Thompson
As Graduate
A. U. Stuart.
As Student
J. S. Waddell.
Transfers :
From Associate Member to Member
E. W. Bennett.
From Graduate to Associate Member
J. Blair.
From Student to Graduate
R. J. Morrison.

GLOUCESTER SECTION
As Associate
C. A. Scovell.
As Graduate
T. J. Maguire.
Transfer :
From Associate Member to Member
B. W. Gregory.

HALIFAX & HUDDERSFIELD SECTION
Transfers :
From Associate Member to Member
A. Webster.
From Student to Graduate
M. A. Cooper.

LEEDS SECTION
As Graduates
D. Linley; R. G. Nield; P. J. Hartwell; D. G. Oxley.
As Students
R. V. Hingorani; A. A. Matthews.
Transfers :
From Associate Members to Members
N. L. Akerman; S. M. Maude.
From Graduate to Associate Member
D. Critchley.

LEICESTER SECTION
As Member
J. I. Ryder.
As Students
A. D. Hammons; R. B. Smith.
Transfers :
From Associate Members to Members
J. H. Devonald; P. K. Digby; T. J. Coombes

LINCOLN SECTION
As Member
B. P. Dabell.
As Associate Member
H. Spencer.
As Graduate
D. G. Sentance.
As Student
K. J. Howkins.
Transfers :
From Associate Members to Members
A. Bourne; R. G. Reid.

LIVERPOOL SECTION
As Student
A. J. O'Rourke.
Transfers :
From Associate Member to Member
J. V. Steele.
From Graduate to Associate Member
A. Gibson.

LONDON SECTION
As Members
S. R. Kilner; C. H. Blackburn.
As Associate Members
F. W. H. Penk; T. R. J. Sexton; P. O'Neill; P. F. Jones; J. Margolis; R. L. Bradley; R. F. Stoyle; K. E. Monger.
As Associates
V. Dhruva; N. R. J. Simmonds.
As Graduates
J. W. Tucker; R G. W. Pye; E. S. Jaques; B. A. Turner; E. G. Woolgar; A. J. Coppen; B. W. Smith; P D. P. Vicary; R. Kell; J. V. Rawson; R. W. Kelsall; J. E. Garton; C. P. G. Bateman.
As Students
J. S. Slavik; A. G. Albone; A. Schmidt; G. E. Mason; R. W. Sach; D. A. Rose; D. O. G. Clarry; D. E. McLaurin.
Affiliated Firm
Associated Machine Tool Makers Ltd.

Transfers :
From Associate Members to Members
C. T. Gould; G. S. Spraggon; C. Evans; R. W. Atkinson; R. J. W. Every; J. Levin; C. R. Croucher; H. J. Rogers; A. C. Keir; R. J. C. Whitaker; A. J. K. Parker; E. J. S. Thomas; W. F. Fisher; A. A. Paget; J. M. Alexander; B. P. Smith; D. W. Wood; H. M. Keegan; C. C. Bates; H. L. Madeley; S. H. J. Freemantle; R. Hutcheson; H. Thaker; F. O. Gloss; S. W. Hoskins; M. D. J. M. Brisby; R. O. Girdlestone; C. W. Ward.
From Graduates to Associate Members
D. S. Flood; R. A. Judd; J. F. Everett; P. Dyce; M. V. Ellis.
From Students to Graduates
B. J. L. Watts; I. Butcher; S. F. M. Samy.

LUTON SECTION
As Associate Members
B. W. James; R. B. Hunter.
As Graduates
P. Roake; C. Brown; G. M. Mitcheson; K. A. Startin; M F. J. Frost; R. Brown; T. B. Shaw.
As Students
J. H. Whittaker; L. E. Almond; F. Flowers; A. E. Smith; R. A. Loxley.
Transfers :
From Graduates to Associate Members
J. S. Harman; D. Priestley; A. M. Warr; P. A. L. Signorini.

MANCHESTER SECTION
As Member
W. Cusworth.
As Associate Members
N. J. Jones; R. Fielding.
As Students
J. T. A. Morris; T. E. F. Hollinshead; D. E. Living.
Transfers :
From Associate Members to Members
A. E. Kay; A. Ormerod; J. Renouprez; A. Edwards; W. T. Neill; A. G. Cooper; H. Sykes.
From Graduate to Associate Member
A. A. Davenport.
From Students to Graduates
B. M. Rensler; A. E. Jordon.

MELBOURNE SECTION
As Associate Members
S. E. Silk; R. J. Griffiths.
As Graduates
W. G. Johnstone R. D. Jones.
New Affiliated Firm
Royal Mint.
Transfer :
From Associate Member to Member
A. Pead.

NEWCASTLE SECTION
As Member
W. B. Fenwick.
As Graduate
J. S. Firth.
As Students
J. W. M. Ashton; M. J. Roberts; R. Wyatt; B. J. Parry; J. Greenwell; M. Dobbins; R. R. Whitehurst.
Transfer :
From Associate Member to Member
J. Doyle.

NORTHERN IRELAND SECTION
As Associate Member
W. K. McWilliam.
Transfer :
From Associate Member to Member
T. A. Rose.

NOTTINGHAM SECTION
As Member
K. E. Middleton
As Graduate
B. A. Golding.

OXFORD SECTION
Transfers :
From Associate Members to Members
C. L. Field; A. A. C. Jacobsen.
From Students to Graduates
B. C. Baker; D M. Sellwood.

(continued on facing page)

THE PRINCIPAL OFFI

THE PRESIDENT

Members will have learned with pleasure that **Mr. G. Ronald Pryor,** *President of the Institution for 1959 - 1960, has been elected to a second term of office. Mr. Pryor has over many years served the Institution, in various capacities, with untiring enthusiasm and complete selflessness, and his activities as President, during a particularly arduous year, have rendered even greater the debt which the Institution owes him. In the past 12 months he has travelled over 10,000 miles to visit Sections and Regions in the United Kingdom, and his programme for the current year is no less extensive.*

Mr. Pryor was educated at Wellington College, Salop, and apprenticed, in 1919, to the family firm of Edward Pryor & Son Ltd., of Sheffield, of which Company he is now Chairman and Managing Director. He is also Chairman of Punch Forgers Ltd., of Sheffield. A well-known and widely-respected figure in Sheffield, he is a Past President of the Institution's Section there. He is also a Vice-Chairman of the Council of PERA, on which body he has served since 1950. He has served on the Council of the Sheffield Chamber of Commerce since 1951, and was subsequently appointed Vice-Chairman of the Education Committee of the Chamber.

The Institution is indeed fortunate that Mr. Pryor has agreed to remain in office for a further year, and will unquestionably derive much benefit from his continued advice and guidance.

THE VICE-PRESIDENT

The election to the Vice-Presidency of **Mr. Harold Burke** *will be warmly acclaimed. Mr. Burke has been a member of the Institution since 1932, and has been prominent in Institution activities for many years. including service as Chairman of Council from 1952 to 1954. He is, however, probably best known to the membership for his work as Chairman of the Special Committee on Reorganisation, which in 1952 produced what has come to be known as " The Burke Report ".*

Mr. Burke is Group Joint Managing Director of The Concentric Manufacturing Company Limited.

The Principal Officers (among whom is included the Immediate Past Chairman of Council, **Mr. H. W. Bowen, O.B.E.***) take office on 1st July, 1960.*

OFFICERS, 1960-61

THE CHAIRMAN OF COUNCIL

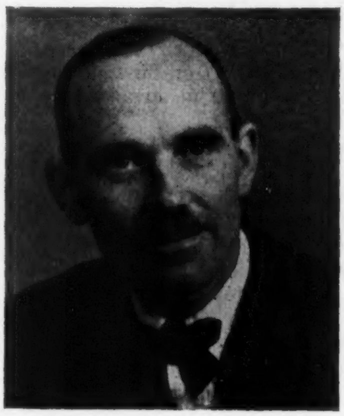
Mr. R. H. S. Turner, M.A.(Cantab.), *Director and Works Manager of Associated Electrical Industries (Manchester) Limited, joined the Institution in 1936, and his election to the Chair will give immense pleasure and satisfaction to his countless friends and colleagues, particularly in the North-West. He holds the additional distinction of being the first member who, having joined the Institution as a Graduate, has ultimately achieved this high office.*

Mr. Turner has made a notable contribution to the success and development of the Institution in the North-West Region. He is a Past President of the Manchester Section, a Past Regional Chairman, and serves currently on the Section and Regional Committees.

Educated at King's College School, Wimbledon, and St. John's College, Cambridge, Mr. Turner was a college apprentice at Metropolitan-Vickers Electrical Company Limited during 1930 - 1932. Following appointments in the Erection, Instrument and Meter, and Plant Departments, he became Superintendent of the Plant Department in 1948, and was appointed Assistant Works Manager, Main Works, Trafford Park in 1952. In 1954, he became Works Manager, and was made a Director in 1955.

In addition to his Institution activities, he is a member of the Technical Policy Committee of PERA, and is Chairman of the Association's Metal Cutting Committee. He is also a member of the Institute of Directors.

Mr. Turner brings to the office of Chairman of Council a well-deserved reputation for balanced judgment and the ability to make rapid and accurate assessments of both situations and individuals, together with a quiet charm which impresses all with whom he comes into contact. The Institution can undoubtedly look forward to a stimulating year under his leadership.



THE VICE-CHAIRMAN OF COUNCIL

Mr. A. L. Stuchbery, M.I.Mech.E., *has been elected Vice-Chairman of Council. Mr. Stuchbery, who is Chief Technical Engineer of The Metal Box Company Limited, and Immediate Past Chairman of the South Eastern Region of the Institution, was one of the earliest members of the Institution, having been elected in 1924.*

He has a long record of continuous service to the Institution and his election to office will be unanimously approved by the membership.

REPORT OF THE MEETING OF COUNCIL

28th April, 1960

THE fourth and last meeting of the Council for the year 1960 - 61 took place at 10 Chesterfield Street, Mayfair, London, W.1, on Thursday, 28th April, 1960, at 11 a.m. The Chairman (Mr. H. W. Bowen, O.B.E.) presided over a meeting of 35 members. Before proceeding with the business of the meeting, he welcomed as visitors Mr. R. H. Cannon, Hon. Secretary of the Luton Section, and Mr. L. P. Coombes, Chairman of the Oxford Section.

Election of Principal Officers, 1960 - 61

The motion by the Chairman that Mr. G. Ronald Pryor and Mr. Harold Burke, respectively President and Vice-President of the Institution for the current year, should be re-elected for a further term of office, was carried by acclamation.

In response, Mr. Pryor said he had found the Presidential office to be a most exacting and exhausting occupation. But it was also a very great privilege and a most rewarding assignment, and he was most appreciative of the confidence vested in him by the Council's action.

Mr. Burke, expressing his thanks to the Council, said he would do his best to continue to serve the Institution on the pattern laid down by Mr. Pryor.

The Chairman also moved the election to the Chair for 1960 - 61, on the completion of his own term of office, of Mr. R. H. S. Turner. Mr. Turner had carried out his duties as Vice-Chairman in exemplary fashion, and his reports on the overseas Sections had been outstanding. *The motion was carried by acclamation.*

Mr. Turner, in response, said he regarded his election as a great honour. He hoped he would be able to live up to the very high standard set by his predecessors. It would be a privilege to serve under the Presidency and Vice-Presidency of Mr. Pryor and Mr. Burke.

It gave him considerable pleasure to nominate as Vice-Chairman of the Council an old friend, Mr. A. L. Stuchbery. Mr. Stuchbery was very well-known to members and had served the Institution for many years in many capacities. He had deservedly earned a reputation for keeping a close eye on the financial side of the Institution. It was long overdue that Mr. Stuchbery should fill the office to which he was nominated. *The motion was carried by acclamation.*

Mr. Stuchbery, in reply, said he had been touched by the invitation to serve as Vice-Chairman of Council. He would carry out faithfully any duties he undertook, with loyalty to the Chairman and, it was hoped, with benefit to the Institution.

Subscription Rates for Members Outside U.K.

The Council adopted the recommendation put forward by the Vice-Chairman, and seconded by Mr. H. Gregory, that the subscription rates for members outside the U.K. be revised as shown on page 433.

Finance

The Council adopted the report on the Institution's finances for the period July, 1959 - March,1960. It appeared likely that the budgeted surplus of income over expenditure would be achieved by the end of the Institution year.

Polish Conference on Teaching Production Engineering

It was reported by the Finance and General Purposes Committee that the Polish Society of Mechanical Engineers had invited the Institution to send a delegate to a Conference on the teaching of production engineering. It had been agreed that the Education and Technical Officer, Mr. F. W. Cooper, should represent the Institution.

Secretary's Commonwealth Tour

The Secretary advised the Council that he was preparing a comprehensive report on his tour which would be circulated to members in advance of the next meeting.

He wished, however, to take this earliest opportunity of expressing his gratitude to the Council for making the tour possible. It had been an experience such as he had never had before, and from a personal point of view, it had been a great adventure.

The most dominant impression he had formed was that there was an infinite future for production engineering and for the Institution in the Commonwealth countries, and he would enlarge on this in his written report.

He had been received with the utmost kindness and interest wherever he went, and in general terms he was convinced that his tour had done a great deal of good.

Sir Walter Puckey, who had been in India and in Australia at the same time as the Secretary, said he could state emphatically that Mr. Woodford had done a very good job indeed. He had heard him expressing the views of the Institution on several occasions during his tour and, in Sir Walter's view, he was a very worthy representative.

Formation of Indian Council

Sir Walter Puckey advised the Council that he had attended the very impressive inaugural meeting of the Indian Council, held in New Delhi. The day's ceremonies concluded with a reception, to attend which some of the guests had travelled over 2,000 miles. At the invitation of the Indian Council, Sir Walter had addressed the assembly on the Institution's past, present and future activities.

Education

It was reported that the Education Committee were currently reviewing two important documents recently issued by the Ministry of Education: The Crowther Report, and "The Routes into National Certificates and City and Guilds Courses".

Work was also proceeding on the final report of the Practical Training Sub-Committee.

Membership

The Council approved a number of applications for membership and transfer, details of which appear on pages 428 - 429.

In regard to Theses, the Membership Committee had revised the Notes for Guidance issued to candidates submitting a Thesis, and had considered an amended marking scheme.

The Journal

The Editorial Committee reported that "The Production Engineer" had been well-received, particularly by advertisers. The steep and unexpected rise in membership of the Institution over the past nine months had meant that production costs had risen more than was anticipated, but the Journal continued to show a small surplus of income over expenditure.

Discussions were continuing with the appropriate Committees on the publication by the Institution of original research Papers.

The Secretary commented that there was great satisfaction in the Commonwealth with the new Journal. Overseas members, he added, would like to

ANNUAL SUBSCRIPTIONS OUTSIDE U.K.

Grade	*NEW RATE*	*U.K. Rate*	*Differentials*	*Increases*
	£ s. d.	*£ s. d.*	*£ s. d.*	*£ s. d.*
Member	7 7 0	8 8 0	1 1 0	1 11 6
Associate Member ...	5 5 0	6 6 0	1 1 0	10 6
Associate	5 5 0	6 6 0	1 1 0	10 6
Graduate over 35 ...	5 5 0	6 6 0	1 1 0	2 2 0
30 - 35 ...	3 13 6	4 4 0	10 6	10 6
under 30 ...	3 3 0	3 13 6	10 6	—
Student	1 11 6	2 2 0	10 6	—
Affiliated Organisation (per representative)	10 10 0	10 10 0	—	—

(The membership subscription for Australian members to be in £A's. At the present time, the Australian £ is equivalent to 15s. in U.K. £'s.)

The overseas Councils and Sections have agreed that the present capitation fee be abolished, and that the standing charge of 25% of subscription income be remitted to the United Kingdom each year, the subscription income to include:-

Subscription renewals (including affiliated organisations)
Subscription arrears
New Subscriptions
Transfers (additional subscriptions).

(A standing charge of 25% based on last year's accounts would have equalled (to within a few pounds) the amount remitted to the United Kingdom on the 25s. capitation fee. Furthermore, since the increased subscriptions will mean additional income for the overseas Sections, a proportionate amount of the increase will accrue to Headquarters.)

Subject to the Council's agreement, the new subscription rate for all members outside the United Kingdom and the standing charge to be remitted to the United Kingdom each year, will come into operation as from 1st July, 1960.

see the publication of more case study work of a practical nature.

Research

The Chairman of the Research and Technical Committee, Mr. B. G. L. Jackman, reported that in the previous week a most successful seminar on Operational Research had been held at Headquarters, conducted by Professor Shephard of the University of California. (*A report appears on pages* 436 - 437.) The seminar had been oversubscribed, and in response to many requests, would probably be repeated.

Mr. Jackman also drew the Council's attention to the Annual Conference of the European Organisation for Quality Control, which was to be held in London in September, 1960. The theme of the Conference was "Control in Production Quality and Its Value to Industry" and he commended it to all members of the Institution.

The following reports were also received on behalf of the Research and Technical Committee :-

Materials Handling Group

A Sub-Committee of members of the Materials Handling Group within the London area had been formed, the Chairman being Mr. L. W. Bailey. The first official activity of this Sub-Committee was a visit to the Mechanical Handling Exhibition on 11th May. (*See page* 437.)

The Group Committee had undertaken to produce a philosophy of materials handling for publication and work on this was proceeding. Work continued on the report of the Study Group with the Building Research Station, for publication in the Journal.

Computers and Production Control

Three meetings of the Sub-Committee had been held during the quarter, additional members had been co-opted, and it was hoped to produce an interim report this year.

Control of Quality

The Sub-Committee had been reconstituted and an inaugural meeting was held on 24th February. It was planned to supply material for publication in the Journal, drawing attention to the Sub-Committee's aim of creating awareness of the value of product quality and supplying information for its achievement.

The Institution was represented on the Organising Committee for the E.O.Q.C. Conference to be held in London later in the year.

Co-ordination of Production Management Techniques

The Sub-Committee continued its work and aimed to produce an essay, posing rather than solving the problem, within the next 12 months.

Materials Utilisation

This Sub-Committee was now in recess, after the publication of its successful report "Improved Materials Utilisation".

Standardisation

It was reported that the Chairman of the Standards Committee, Mr. R. E. Mills, had been invited to preside over the Sixth Conference of Standards Engineers, organised by the Joint I.Prod.E./B.S.I. Committee. The Conference was now firmly established and had again been fully subscribed. (*A report appears on pages* 427 - 428.)

The Sub-Committee on International Standardisation had met several times during the quarter and had prepared comments on several I.S.O. recommendations.

The Library

It was reported by the Library Committee that a second supplement to the Library Catalogue was in course of preparation. Work continued on the history of the manufacture of the small electric motor, which is intended to illustrate the history of production engineering.

Region and Section Quarterly Reports

The Council discussed very fully policy in regard to Quarterly Reports. It was suggested that the system be changed so that Sections reported quarterly to Regions — and not to Council as at present — and that Regions should report annually to the Council; such Regional reports to form the basis of Council discussion.

It was finally agreed that this proposal should be referred to the Finance and General Purposes Committee, and subsequently to the next meeting of Council for further consideration.

Liaison with Overseas Sections

The Vice-Chairman of Council reported that he had received from some overseas Sections letters expressing appreciation of the Secretary's visit. There was also a communication from the Chairman of the Canadian Section, enquiring about the possibility of a visit from Mr. Woodford, accompanied by a senior member of the Council, sometime during 1960.

The Vice-Chairman had also received a letter from the Chairman of the Bombay Section, conveying thanks for the work done by Sir Walter Puckey, Mr. Woodford and Mr. F. W. Cooper on their recent visit.

Mr. Steer, President of the Australian Council, had advised the Vice-Chairman that he hoped to attend the next meeting of the Council.

Obituary

The Council recorded with deep regret the deaths of the following members :-

Members: F. Guylee; R. W. Harris; H. Ellis; G. Marsh; J. W. Messinger; H. G. Ramsell; L. W. Smith; Col. C. G. Warren-Boulton.

Associate Members: A. C. Badger; J. Buckley; J. Boddy; J. S. Sanders; R. B. Scott.

Graduates: P. L. Felton; K. K. Kapur.

Other Business

Before concluding the business of the meeting, the Chairman, Mr. H. W. Bowen, O.B.E., expressed his thanks to all those members who had served on the Council during his two years of office. He thanked them not only for their hard work, but also for the support which they had given him personally. He also acknowledged with gratitude the support he had received from the President, Mr. Pryor, his predecessor, Lord Halsbury, and the Vice-Chairman, Mr. Turner. Last, but by no means least, he thanked Mr. Woodford and Mr. Caselton for their assistance, which had been of a very high order. Everything possible had been done to make his path an easy one.

The President said that Mr. Woodford had received a number of compliments, but one point had been missed. This was that he had retained the services of a first lieutenant so efficient that during Mr. Woodford's very long absence at the busiest time of the year, the affairs of the Institution at Headquarters had been continued efficiently and smoothly, without trouble of any sort. The President therefore moved that the Council should record their appreciation of all the work done by Mr. Caselton during this period. *The motion was carried by acclamation.*

Mr. J. Winskill moved a hearty vote of thanks to Mr. Bowen for his able Chairmanship of the Council during the last two years. Every man brought to the Chair his own individual talent, and in Mr. Bowen's case it was his aptitude for saying to somebody, when something had to be done : "You are the man to do it", whether it be in London or 200 miles away, and then waiting for the bread which he had cast upon the waters to come back. Mr. Bowen had done that with great success, and members of Council had enjoyed sitting under his excellent Chairmanship.

The vote of thanks was carried by acclamation.

Date of Next Meeting

It was agreed that the next Meeting of the Council should take place on Thursday, 21st July, 1960, at 10 Chesterfield Street, Mayfair, London, W.1, at 11 a.m.

COUNCIL ELECTIONS, 1960-61

The number of vacancies for Elected Members of Council was nine; (eight Members and one Associate Member). As the number of nominations received equalled the number of vacancies, no ballot was necessary. The following members are, therefore, elected to serve on Council for the year commencing 1st July, 1960.

Members :

C. E. Darlington	J. G. Noble	J. W. H. Smith
P. Jeffrey	P. J. Shipton	J. H. Winskill
R. E. Leakey	L. P. Simpson	

Associate Member :

G. V. Bevan

OPERATIONAL RESEARCH SEMINAR

ON 19th - 20th April, 1960, the Institution's Council Chamber was filled to capacity with members attending the first seminar on Operational Research to be organised by the Institution.

Mr. B. G. L. Jackman, in opening the seminar, stated that the Research and Technical Committee, of which he had the honour to be Chairman, was increasingly aware that modern scientific techniques as applied to production engineering were developing rapidly. In order to keep members abreast of these developments, the Institution had taken the opportunity offered by the European Productivity Agency to utilise the services of specialist consultants from the U.S.A.

The first of these seminars would be conducted by **Professor R. W. Shephard,** of the University of California. He went on to say that Professor Shepherd, after graduating in Mathematics and Economics from the University of California, had held various posts in industry and had also undertaken various assignments for U.S. Government Agencies, these being mainly in the field of Industrial Application of Statistics and Operational Research techniques.

In 1956 he was appointed to his present position as Professor of Industrial Engineering and during this time he once again undertook various research projects. In addition, he was the author of a number of publications on economic and mathematical subjects.

Professor Shephard in presenting, in a clear and witty style, various aspects of Operational Research, showed the members of the seminar that mathematical methods could be of immense value in overcoming industrial problems. He demonstrated by means of worked examples methods of tackling such problems as machine shop loading; least cost scheduling of deliveries; production planning for minimisation of manufacturing and inventory costs and problems of inter-process storage.

The seminar was divided into four main sessions, the first of which dealt with linear programming; the example worked was in determining a machine loading problem with linear constraints. A graphical solution was worked out, but Professor Shephard recommended that the majority of these problems would be better dealt with by the "Simplex Method", developed by Philip Wolfe of the Rand Corporation, since the number of constraints met with in actual practice did not allow graphical solutions to be used.

In non-linear problems, particularly where the objective to be optimised could be expressed as a sum of separable concave functions, the method normally adopted was to break the problem down to one of a linear nature.

For both linear and non-linear problems the Simplex method utilised the concept of the slack variable which reduced inequalities in the constraints to those of equalities.

Mr. Bernard Jackman, Chairman of the Research and Technical Committee, opens the Seminar. Professor Shephard is on his left.

Part of the Seminar in session.

Where the number of constraints was large and manual computation became exceedingly tedious, the use of a computer was desirable. Standard programmes were now available and at the present time could accommodate a total of approximately 200 constraints.

Professor Shephard was of the opinion that this number had not been increased because it was felt that it should be possible to simplify most industrial problems to well below this number.

Where optimisation of the programme was not a simple linear function, because of the existence of certain relationships, and the discrete nature of the assignment variables, recursion methods, usually described as Dynamic Programming, were used. Two case histories were worked, the first on minimisation of manufacturing and inventory costs and the second on least cost scheduling of daily local deliveries of a factory making glass bottles.

In the last session of the seminar Professor Shephard briefly covered the problems of queuing, and the specific cases where they arise and can be dealt with by many mathematical processes available today.

In conclusion, Professor Shephard pointed out that in his experience the concepts of Operational Research techniques could be dealt with by engineers with only a limited knowledge of mathematics at their command, but if the full benefits of these techniques were to be fully realised, then a good working knowledge of mathematics and statistics was necessary, particularly when attempting to deal with situations containing factors liable to variation.

FORMATION OF MATERIALS HANDLING GROUP (LONDON SECTION)

On Friday, 4th March last, a meeting was held at the Institution's Headquarters to discuss the possibility of setting up a London Section of the Materials Handling Group, and about a dozen interested members attended.

Mr. F. E. Rattlidge, the Chairman of the Institution's Materials Handling Group Committee, who had come specially from Birmingham to attend the meeting, outlined the aims of the Materials Handling Group and gave details of the attempts being made to stimulate interest in other Sections of the Institution. As a result of this initial meeting it was decided to set up a London Section of the Materials Handling Group. The members attending constituted themselves, for the time being, a Committee, under the Chairmanship of Mr. L. W. Bailey.

Since that time, two further meetings have been held and by the time these notes appear the Committee will have met once again, on 2nd June.

It is the intention of the London Section Committee to organise various activities connected with Materials Handling, and it is hoped eventually to build up a very active Group.

There is at present under consideration a number of works visits and the organisation of seminars dealing with Materials Handling and allied subjects, and it is also intended to initiate some research projects.

These various activities are, however, wholly dependent upon the support of the members of the Institution and of the London Section members in particular, and the Committee will welcome hearing from all those having an interest in this important sphere of the production engineer's work.

Membership of the Materials Handling Group is of course confined to members of the Institution of Production Engineers (all grades) but it is free, and application forms are readily available from the Head Office at 10 Chesterfield Street, Mayfair, London, W.1.

During the 1960 Mechanical Handling Exhibition at Olympia, the London Section Group took the opportunity of making an official visit, and were honoured by having with them the President of the Institution, Mr. G. Ronald Pryor. This photograph, taken during the visit, includes (left to right) Mr. D. Gwynne; Mr. P. H. Steer, Chairman, Brighton Sub-Section; Mr. B. L. Soane; Mr. L. Holt; Mr. R. H. Norris; Mr. L. Cook; Mr. W. F. S. Woodford, Institution Secretary; the President; and the Committee Chairman, Mr. L. W. Bailey.

For those members centred along the South Coast the Brighton Sub-Section are keen to build up a group and those interested should contact Mr. D. Gwynne, at Underwood Business Machines Ltd., Brighton.

NORTH MIDLANDS REGIONAL CONFERENCE

The One-Day Conference organised by the North Midlands Region of the Institution, on the theme, "The Production Engineer in a Changing Economy", attracted an attendance of some 200 members and their ladies, who enjoyed a most interesting day.

The delegates were welcomed by the Mayor of Derby, who is shown (right) with the Mayoress; Mr. A. G. Clark, Regional Chairman; Mr. Harold Burke, Vice-President of the Institution and one of the Conference speakers; and Mr. F. Morley, Chief Design Engineer, Rolls-Royce Ltd. (Aero-Division), who also gave a Paper. A report of the proceedings will appear in the August issue of "The Production Engineer".

Photograph by courtesy of "Derby Evening Telegraph"

NEWS OF MEMBERS

Mr. W. G. Ainslie, Member, has been promoted to Senior Lecturer in Engineering Production in the University of Birmingham. Mr. Ainslie is Chairman of the Institution's Education Committee.

Lt. Col. E. Hebblethwaite, Member, is now Production Manager of 34 Base Workshop, R.E.M.E., Wellington, Salop.

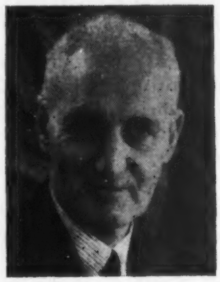
Mr. F. G. Phipps, Member, has now relinquished his appointment as Director in charge of Production, in view of his impending retirement from Davy United Ltd. on 30th June, 1961. Until his retirement, Mr. Phipps will remain a Director of Davy and United Roll Foundry and of Davy and United Instruments Limited.

Mr. E. L. Tuff, Member, has been appointed a Director and Deputy Chairman of Peco Machinery Sales (Westminster) Limited.

Mr. E. W. Bird, Associate Member, has now left his position as Works Manager to Messrs. C. Abrey & Co. Ltd., and has taken up an appointment with Messrs. Bailey (Malta) Ltd., of Valetta, Malta, G.C.

Mr. E. N. Corlett, Associate Member, until recently Tube Investments Research Fellow, has now been appointed D.S.I.R. Senior Research Fellow in the Department of Engineering Production in the University of Birmingham. Mr. Corlett is a Corresponding Member of the Institution's Papers Committee.

Mr. Arthur Sykes, O.B.E., Member, a Past Chairman of the Yorkshire Section, was recently presented by the British Gear Manufacturers Association with a gold medal, to mark his outstanding services to the industry. Mr. Sykes, who is technical consultant to the David Brown Gear Group, is the first member of the B.M.G.A. to receive this honour.



Mr. J. Pearson, Associate Member, has recently been transferred from the Automobile Division of David Brown Industries Ltd., to the Tractor Division of the same concern where he has taken up an appointment as Assistant Works Engineer.

Mr. R. D. Turner, Associate Member, has been appointed Managing Director of Metal Castings Ltd.

Mr. J. C. Wood, Associate Member, is now Works Manager with I. Ross & Co., Morley, Yorks.

Mr. R. Archibald, Graduate, is now a Junior Production Engineer with The Glacier Metal Company, Kilmarnock.

Lieutenant J. H. A. Mason, Graduate, is now Air Engineer Officer at 89 Naval Air Squadron, Lossiemouth, Morayshire.

Mr. F. J. Silvester, Graduate, has recently left the United Kingdom to take up an appointment on behalf of his firm, with the Union Carriage & Wagon Co. (Pty.) Ltd., Transvaal, South Africa. Mr. Silvester will be in South Africa for at least 12 months.

DIARY FOR 1960-61

AUGUST 24-28 ... ... **Symposium,** at The College of Aeronautics, Cranfield.
Subject: **"Machine Tool Control Systems"** (see Supplement).

SEPTEMBER 17 ... ... **Fourth Graduate and Student Convention,** Birmingham (see Supplement).

SEPTEMBER 21 ... ... **The 1960 E. W. Hancock Paper,** in London.

OCTOBER 12-14 ... ... **National Conference,** at Brighton.
Theme: **"Modern Trends in the Manipulation of Metals"** (see Supplement).

NOVEMBER 2 ... ... **Annual Dinner,** at the Dorchester Hotel, London.

NOVEMBER 10 ... ... **The 1960 Sir Alfred Herbert Paper,** at The Royal Institution, London.

JANUARY 12-13 ... ... **Eighth Aircraft Production Conference,** Southampton.

Hazleton Memorial Library

ADDITIONS

Members are reminded of the following Library rule, which is frequently ignored:

"The initial loan period is one month, and borrowers may keep books and periodicals for further periods of one month, if they ask the Librarian, and if no other borrower wants them. Applications for renewal may be made by post or telephone."

Muchnick, Samuel N. **"Adhesive Bonding of Metals."** Presented at Rubber and Plastics Session, American Society of Mechanical Engineers Meeting, June, 1955. *Philadelphia, the Franklin Institute,* 1955. .15 *pages Graph.*

Niedzwiedzki, Antoni. **"Manual of Machinability and Tool Evaluation: a treatise built upon advanced European and American concepts and theories, and the results of the author's own experimentation and practical experience in engineering and machine shop."** *Cleveland, Ohio, Huebner Publications,* 1960. 97 *pages. Illustrated. Diagrams. Graphs, Tables.* $6.00.

In this book the author attempts to bridge the gap between theory and practice, and between European and American concepts of machining with carbides and high-speed steel tools. The ideas of many technical groups in Europe and the United States have been evaluated and analysed by the author, who has combined them with the results of his own experiments, calculations and observations. The manual shows how it is possible to predict the amount of tool wear obtained in a given cutting time from a given set of machining conditions, and to calculate power consumption in advance of machining. The manual's spiral binding makes it easy to hold and work with.

Contents:- *Chapter* 1. *Scope of the report.* Objective—Tool wear — Designations — Mathematics. *Chapter* 2. *Tool life formulas.* General remarks — Tool life criterion — Cutting speed influence — Chip load influence — Depth of cut influence — Diameter turned influence — Hardness influence. *Chapter* 3. *Power consumption formulas.* General remarks — Cutting Speed influence — Chip load influence — Chip load and workpiece hardness. *Chapter* 4. *Cutting tests.* Tool geometry — Test records — Test evaluation. *Chapter* 5. *Test results.* Small scattering of test results — Large scattering of test results — Abrasive steels. *Chapter* 6. *Computation of Standards.* Machinability classification — Development sheets — Recommendation sheets — Crossed charts. *Chapter* 7. *Practical Conclusions.* Material specifications — Tool inspection — Machine tool selection — Possible extension of applied methods. *Appendices.* Bibliographical references—Index to charts and tables—Index to figures and graphs.

Ripnen, Kenneth H. **"Office Buildings and Office Layout Planning."** *London, New York, etc., McGraw-Hill Book Company,* 1960. 182 *pages. Illustrated. Diagrams. Plates.*

The first half of this book deals with the planning of offices and office space administration. The remainder deals with office construction, and the factors which management needs to consider in its choice of site, architect, rent of building and so on.

Shephard, Ronald W. **"Non-linear Programming."** (Distribution between products manufactured with the same facilities and resources.) *Paris, Organisation for European Economic Co-operation, European Productivity Agency,* 1960. 50 *pages. Mimeo.* (E.P.A. Project 6/02-AI- Operations Research.)

Smith, J. Sandford. **"Punched Cards."** *London, Macdonald and Evans,* 1960. 161 *pages. Illustrated. Diagrams.* £2 10s. 0d.

Punched cards are used chiefly for accountancy and allied office procedures. The reason for this, in the opinion of the author, is that most of the people concerned in installing punched card machines, are, like himself, accountants and not engineers. But, he says, punched cards should by their very nature be an almost perfect medium for controlling production. The three production control case studies presented in this book should be of especial interest to production engineers.

The first part of the book explains what punched cards are, how they work, and the equipment and types of equipment necessary in their operation. The author then discusses the managerial aspects of punched card installation: when and in what circumstances to instal punched cards; how to prepare for a punched card installation (e.g., staff training; arranging a smooth changeover from conventional methods; type of accommodation and layout necessary); The organisation of a "punched card department"; the adaptation and design of procedures to fit punched card operation. The author then describes actual and potential relationships between punched cards and other type equipment. In assessing the future development of punched cards, he says that there is a probable link between punched cards and full computer application.

There follow 15 case studies showing the application of punched cards to day-to-day routines of business, grouped under the following heads:- sales accounting; payroll; stock control; production control; unusual applications. This section is illustrated by pictures of currently available cards, and the companies whose procedures are described are named.

Although there is necessarily emphasis laid on non-engineering applications of punched cards, there is much in this book to interest production engineers.

Svensson, Yngve. **"Arbetsstudier i England."** *Stockholm, Arbetsstudietekniska Institutet,* 1959. 73 *pages. Illustrated.*

The Swedish Work Study Institute, publisher of this report, studies the development and application of work study in Sweden and other countries On its behalf, the author visited England in 1959, and spent five weeks visiting government, professional, teaching, research and industrial establishments, which either practice work study or promote its use. In this well-arranged report he describes their policies and practices. Twenty-nine such organisations are listed in the directory section, together with the responsible officer or "contact". The author concludes his report by expressing the hope that it will help to establish co-operation between English and Swedish work study people. "We have so many interests in common with the English, that a continuous exchange of experience should be of the greates value for us both." In Swedish.

Thompson, A. G. **"High Productivity in Heavy Engineering: Production, Inspection and Cost Control in Welded Fabrication."** *London, Iliffe,* 1960. 339 *pages. Illustrated. Diagrams.* 65s.

The introduction of welded fabrication into heavy engineering has led to the development of a whole range of new techniques, which have considerably altered the production methods of many firms and industries (e.g., the shipbuilding industry). This book, as far as possible, avoids repeating what has already been published about welding and concentrates on the technology which has been built up round welded fabrication: accurate dimensioning, cutting machines, including computer controlled flame profiling machines, and welding machines. There is a chapter on the latest metal-working processes essential for efficient fabrication, which includes details of the various machines which have been evolved for preforming sheet and plate. The second half of the book is devoted to costing.

Contents:- Introduction — Layout and organisation of modern fabrication shops — Dimensioning for accurate fabrication — Metal working processes — Assembly and handling — Welding processes — Quality control and inspection — Cost in relation to output — The time to do the job — Use of cost data — Productivity improvement.

Tin Research Institute, Greenford, Middlesex. **"The Properties of Tin."** *Greenford, the Institute,* 1954. 55 *pages. Tables.* 2s. 6d.

Town, H. C. **"Cutting Tools, Jigs and Fixtures."** *London, Odhams Press,* 1960. 247 *pages. Illustrated. Diagrams.* 25s.

The first part of this book surveys recent developments in various types of cutting tools, and introduces cutting materials such as ceramics. Diamond tools are dealt with also. The basic features of cutting tool design are considered including such matters as negative rake cutting for the efficient utilisation of cemented carbide tools, and the design of cutters for down-cut milling and square-hole milling. Heat treatment, cutting speeds and feed rates, and form tool design and calculations are included. Jigs and fixtures are described and discussed in the second part, and examples are given of a wide range including pneumatic and hydraulic devices. Although the book is not concerned with machine-tool design, a comparison of machining methods is presented, and a selection of machines and equipment is described for unit construction, attachments, or conversion from single to general purpose machines. There are sets of worked examples in cutting tool and jig and fixture design. In writing this book, the author, who is Principal of Keighley Technical College, has had in mind technical college students, taking courses in tool design and principles of engineering production, and those working for the appropriate examinations of the Engineering Institutions and the City and Guilds examinations in Machine-Shop engineering.

Contents:- Theory of metal cutting — Cutting materials — Heat treatment and grinding of tools — Lathe and planing machine tools — Drilling, boring and reaming tools — Milling cutters — Broaching practice — Cutters for spur and work gearing — Worked examples in tool and cutter design — Economics of jig and fixture practice — Factors in design — The choice of machining methods — Selection of machines and tooling equipment — Pneumatic and hydraulic jigs and fixtures—Router, welded and non-metallic jigs and fixtures — Worked examples in jig and fixture design

Wiggin (Henry) and Company Limited, Birmingham. **"Wiggin Electrical Resistance Materials."** *Birmingham, the Company,* 1952. 102 *pages. Tables.*

The Council of the Institution

1960/1961

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H. Burke

Chairman of Council

R. H. S. Turner

Vice-Chairman of Council

A. L. Stuchbery

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B. G. L. Jackman (*Research and Technical*)
F. C. Cooke (*Papers*)
L. W. Bailey (*Library*)
W. G. Ainslie (*Education*)
R. E. Mills (*Standards*)
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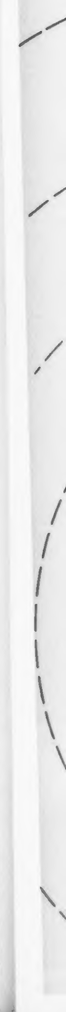


International Machine Tool Exhibition, London, 1960.
Parkinson machines will be demonstrated on Stand 63, Grand Hall, Olympia, June 25 to July 8.

P381-18

CHA
I

Churchill

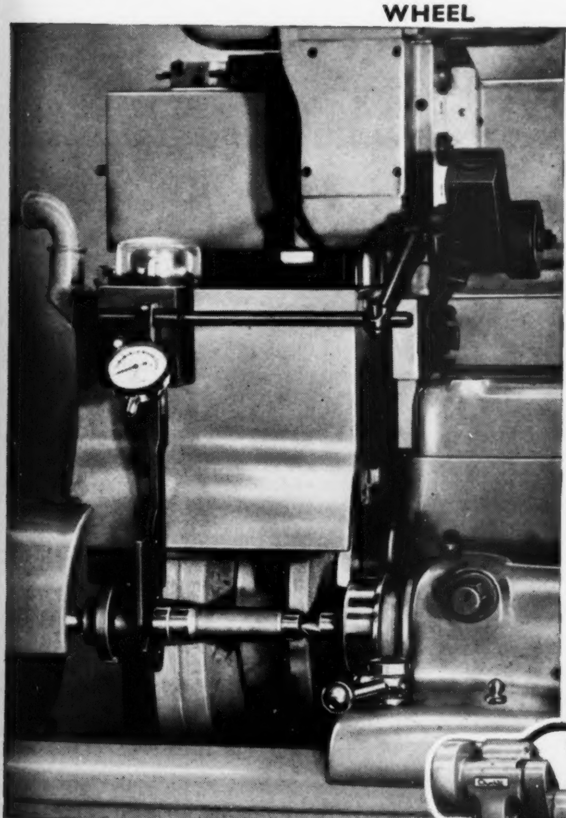
AUTOMATIC

SIZING OF WORKPIECE

TRUING OF GRINDING WHEEL

COMPENSATION FOR WHEEL TRUING

CYCLE CONTROL FOR NUMBER OF WORKPIECES



on

Model 'BW'
Plain
Grinding Machine

THE CHURCHILL MACHINE TOOL Co Ltd
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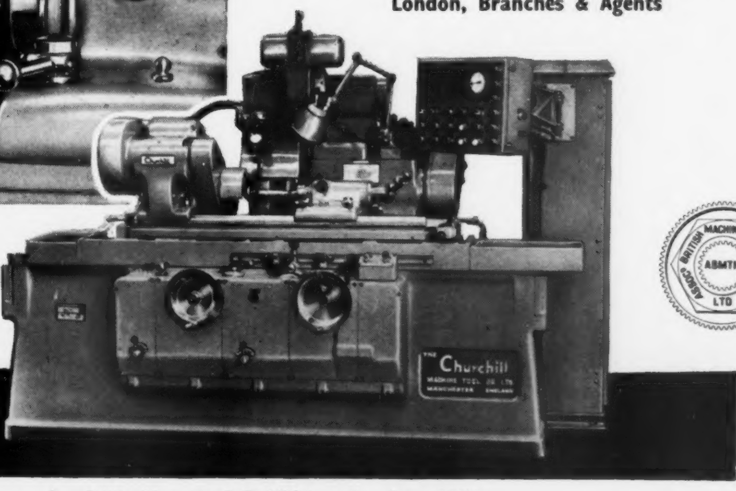

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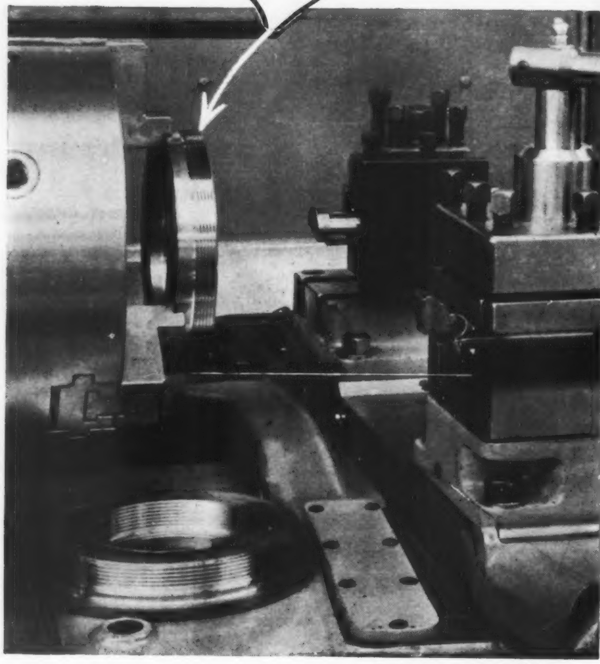
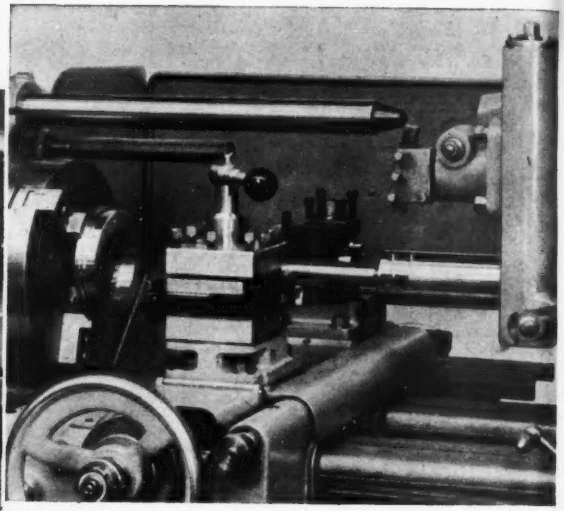
C675-ID

Maximum Production Special Tool Layouts

SCREWED RING





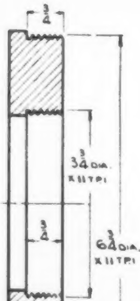
Ward

No. 7 TURRET LATHE

FITTED WITH 12in TUDOR 3-JAW CHUCK

STEEL FORGING

40 Ton Tensile Steel
En.8.



All Tungsten Carbide Cutting Tools

DESCRIPTION OF OPERATION	Tool Position		Spindle Speed R.P.M.	Surface Speed Ft. per Min.	Feed Cuts per inch
	Hex. Turret	Cross-slide			
1. Grip Forging in Three-Jaw Chuck	—	—			
2. Turn Outside Diameter	—	Front 1	416	765	266
3. Undercut and Face Flange and Chamfer	—	—			
o/dia.	—	Front 2	416	765	Hand
4. Screwcut o/dia. × 11 T.P.I. (7 cuts)	—	Front 3	280	495	11 T.P.I.
5. Face End	—	Front 1	675	1193	52
6. Bore, Undercut and Chamfer	1	—	416	408	134
7. Screwcut Internal Thread 11 T.P.I.	—	—			
(7-cuts)	—	Rear	416	408	11 T.P.I.
8. Remove Part from Chuck	—	—			

Total Floor-to-Floor Time for above operations: 5 minutes.

NOTE:— Time for cutting external thread 11 T.P.I. (7 cuts) *40 seconds*
Time for cutting internal thread 11 T.P.I. (7 cuts) *36 seconds*

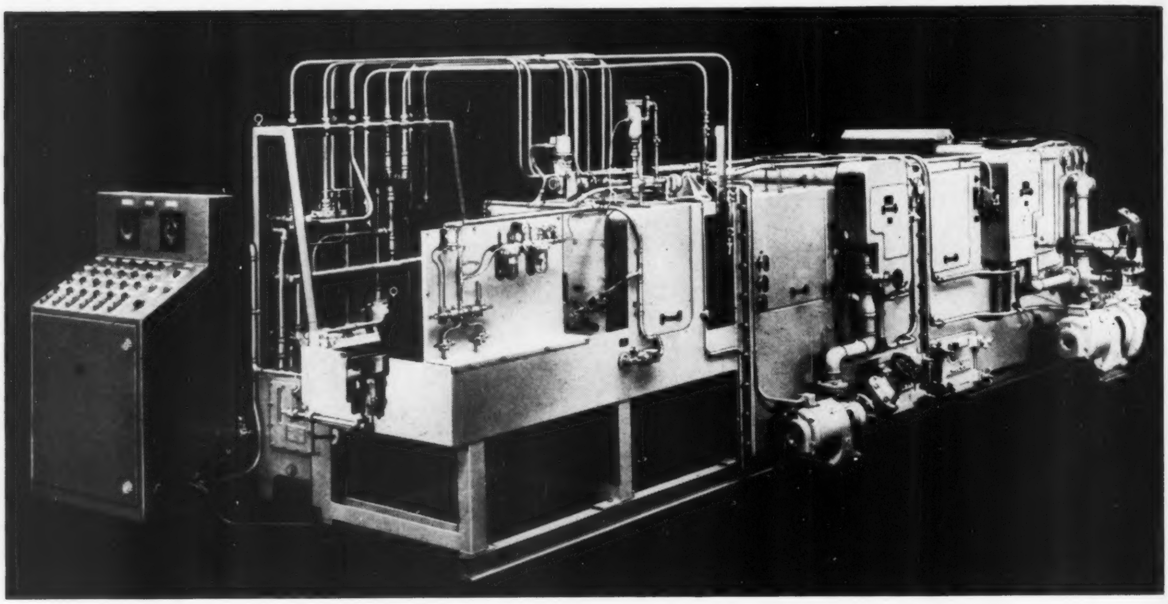
H·W·WARD & CO LTD

SELLY OAK
BIRMINGHAM 29
TELEPHONE SELLY OAK 1131

BRITISH MACHINE TOOL MAKERS ASSOC. LTD ABMTM

W654

International Machine Tool Exhibition, London, 1960.
Ward Lathes will be demonstrated on Stand 205, Empire Hall, Olympia, June 25 to July 8.



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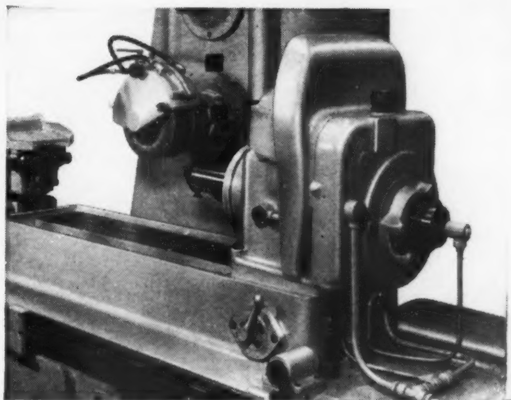
SHAFT GRINDING MACHINE

ADAPTED FOR SPECIAL

APPLICATION BY

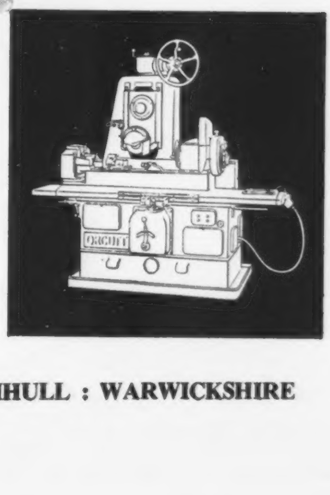
WOLSELEY

The Orcutt Hydraulic Shaft Grinding Machine was installed by Morris Motors Limited at their Coventry Works for accurate grinding of angular lug faces on syncromesh hubs for the new Wolseley 6 - 99.



Write for our latest literature on the Orcutt 20 in. and 36 in. Grinding Machines.

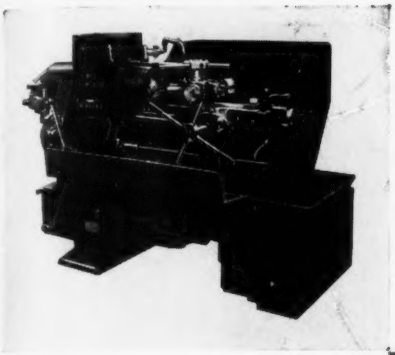
Comprehensive gear grinding service
Gear manufactured and ground complete
Makers of the Orcutt range of gear and spline grinding machines and measuring machines



The Gear Grinding Co. Ltd.

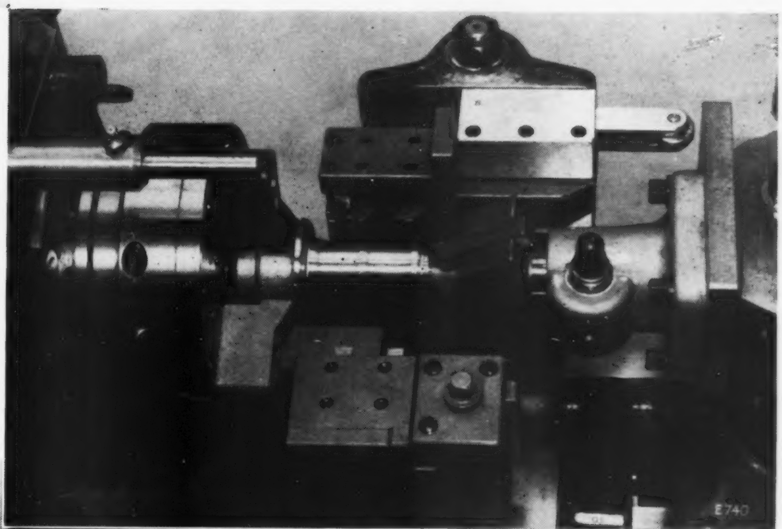
CRANMORE BOULEVARD : SHIRLEY : SOLIHULL : WARWICKSHIRE

Telephone : SHIrley 2231 (6 lines) Telegrams : Orcutt, Birmingham



HERBERT

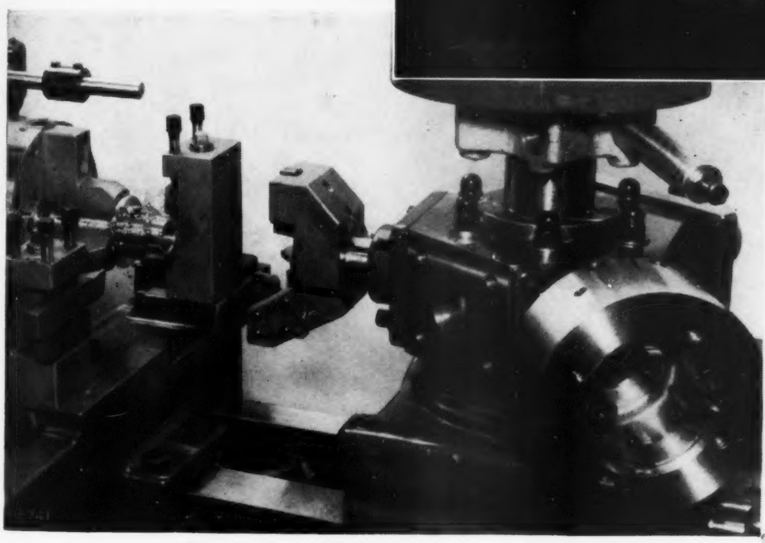
No. 2 FLASHCAP LATHE for the high production of non-ferrous work, including threaded components requiring frequent spindle reversals.



First operation for producing fire hose couplings from brass pressings on a machine fitted with a special cross-slide and profiling slide.

The tools on the profiling slide are fed forward by operation of the cross-slide while the component is supported in the bore by a revolving steady. The turret is then moved forward to actuate the profiling slide and so turn the two 32 mm. diameters simultaneously. Continued movement of the turret radiuses the end and chamfers the bore.

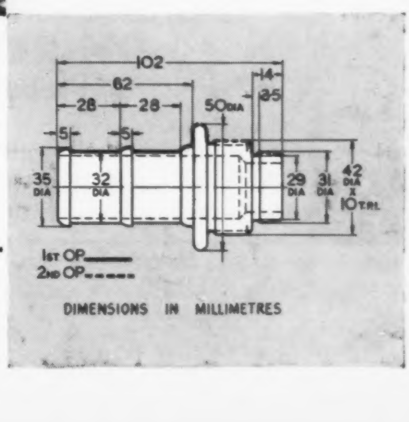
Floor to floor time—12 seconds.



In the second operation on the couplings, the 42 mm. diameter, the taper, the radius on the end and the chamfer in the bore are simultaneously machined with tools held in a standard combined holder on the turret.

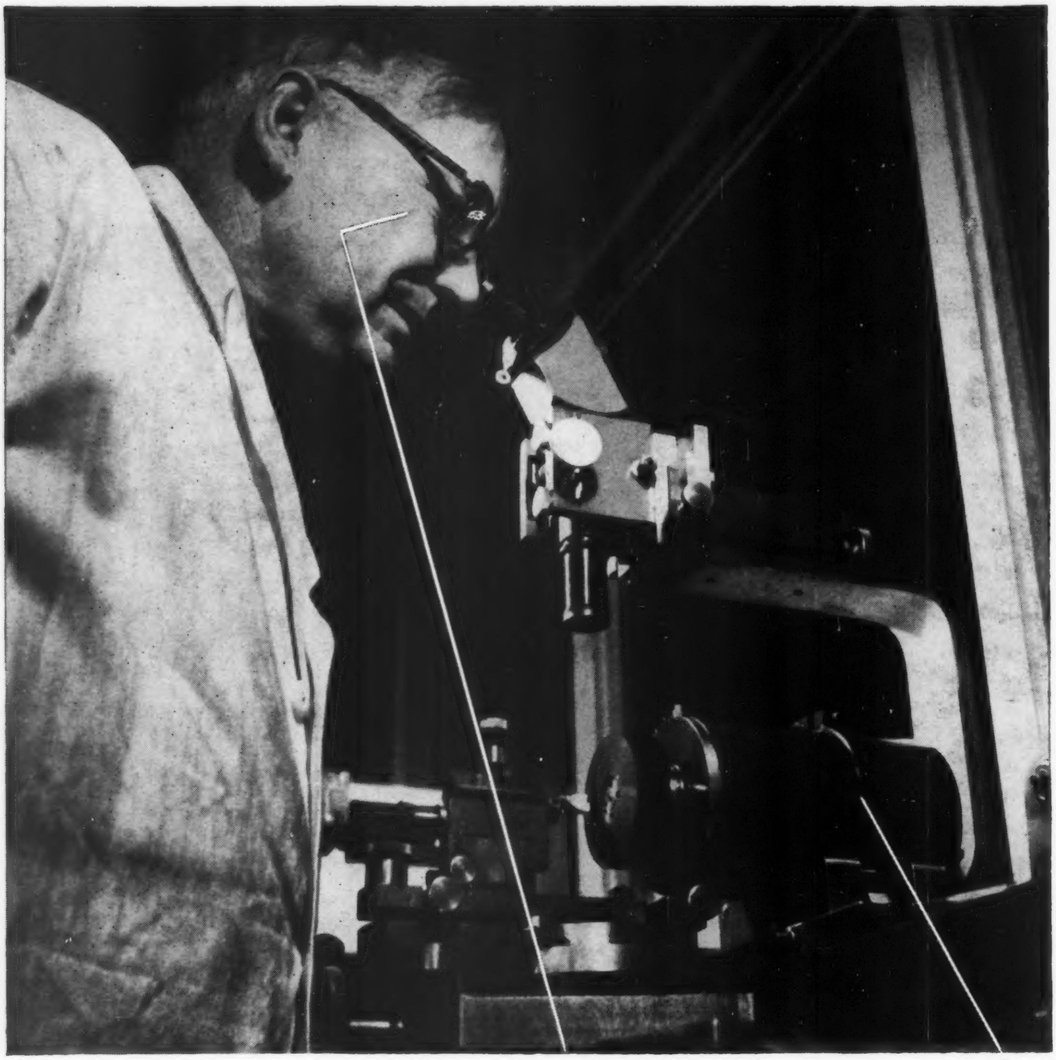
Tools held on the cross-slide are then used to radius the flange, undercut and chamfer the thread diameter and undercut the taper. The 42 mm. thread is cut with a $2\frac{1}{2}$ in. Solid Adjustable Diehead mounted on the third turret face.

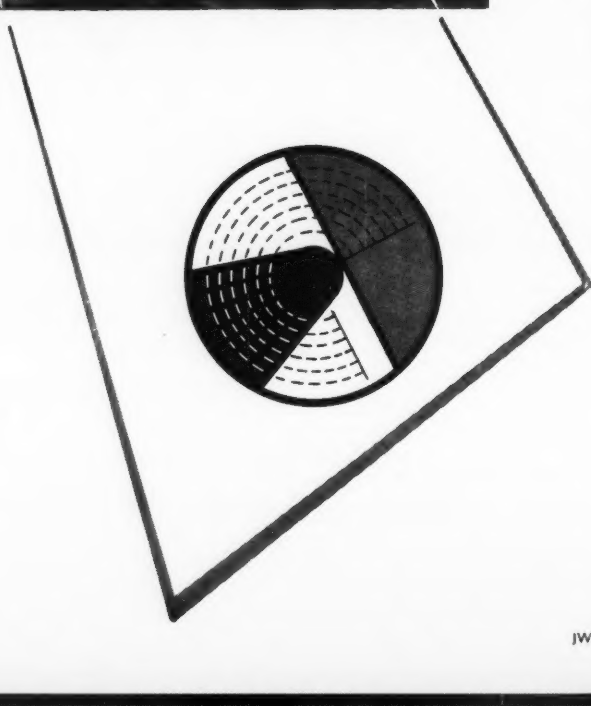
Floor to floor time—25 seconds.

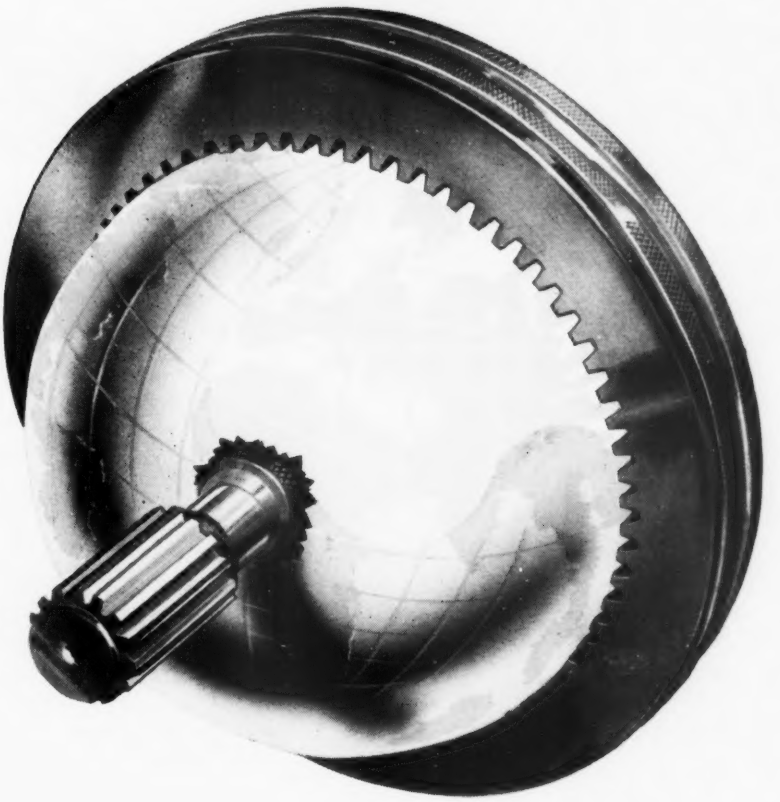


Most Herbert Capstan and Combination Turret Lathes are now available for early delivery.

ALFRED HERBERT LTD., COVENTRY

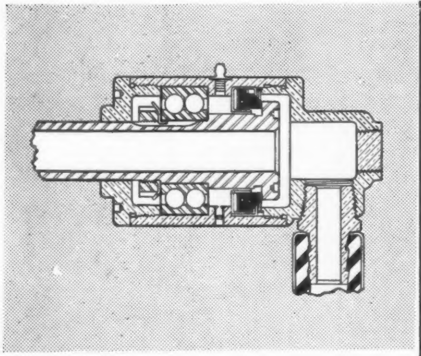




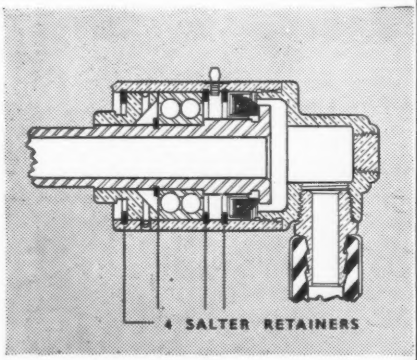


How costs are cut with SALTER RETAINERS

Salter retainers simplify design of air, water, steam union, with great savings



THE OLD WAY Air, water, steam union involved drilling, threading and milling operations. Maintenance was difficult.



THE SALTER WAY Salter retainers permit rapid, simple assembly and maintenance with a reduction in manufacturing costs.

MATERIALS SAVED	
decreased wall thickness of housing	2/9¾
eliminated bearing lock nut and washer	7¾
MACHINE OPERATIONS ELIMINATED	
bore, undercut, and tap cap end of housing	1/4¾
locate cap on arbor, and chase threads	1/-
drill spanner wrench holes	4¼
cut thread on rotor for lock nut	3¾
mill slot in thread for tang on lock washer	7½
drill spanner wrench holes in rotor	4¼
ASSEMBLY OPERATIONS ELIMINATED	
install lock washer, tighten lock nut, bend lug	8½
assemble cap into housing	4
TOTAL SAVING WITH SALTER RETAINERS	8/6½

*

4 SALTER RETAINERS simplify design, assembly and maintenance with a saving of 8/6½ per unit

1760 SALTER 1960 BI-CENTENARY YEAR

NEATER — MORE POSITIVE — PERMANENT RETAINING

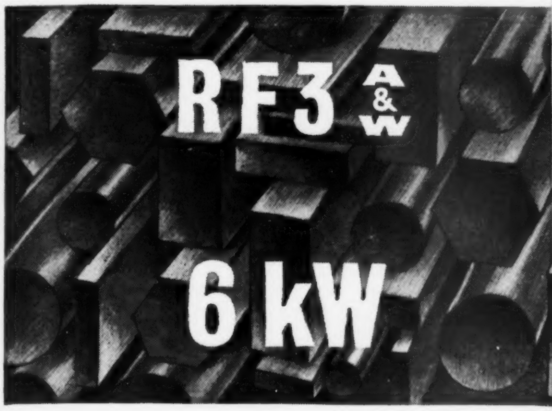
SALTER "TRUARC" Regd. Trade Mark

Circlips *Fasteners* *Retainers* *Fixes*

Geo. Salter & Co. Ltd., West Bromwich. Spring Specialists since 1760

H-W.481

Another addition to the PYE Range of Induction Heaters



INDUCTION HEATING UNITS

These 6 kW induction heaters have been designed for continuous operation and incorporate the latest design techniques. The generators are of medium impedance output being suitable for general purpose heating applications such as annealing, brazing, hard and soft soldering, hardening and tempering. The availability of a high work coil kVA in association with multi-turn coils permit the heating of a wide range of ferrous and non-ferrous loads.

The oscillator value may be either air cooled (Type R.F. 3/A) or water cooled (Type R.F. 3/W) depending upon customer requirements. With the R.F. 3/A water is used only for cooling the tank and work coils. In the case of the R.F. 3/W a common water supply is employed for cooling the oscillator valve, tank and work coils.

Due to the simplicity of operation unskilled labour may be employed enabling production costs to be reduced. The controls, indicator lamps, anode current meter and process timer are conveniently grouped on the front panel. Compact design allows the equipments to occupy the minimum of floor space. The equipments in operation are extremely dependable as a result of advanced design and the use of components of proved reliability.

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FREE TECHNICAL ADVICE *is offered on the applications of R.F. heating to Tempering, Brazing and Hardening processes etc. Our technical representatives are at your service, or we will send you full details—please tick the appropriate box in the coupon.*

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Please send me details of Pye Process Heating Equipment.

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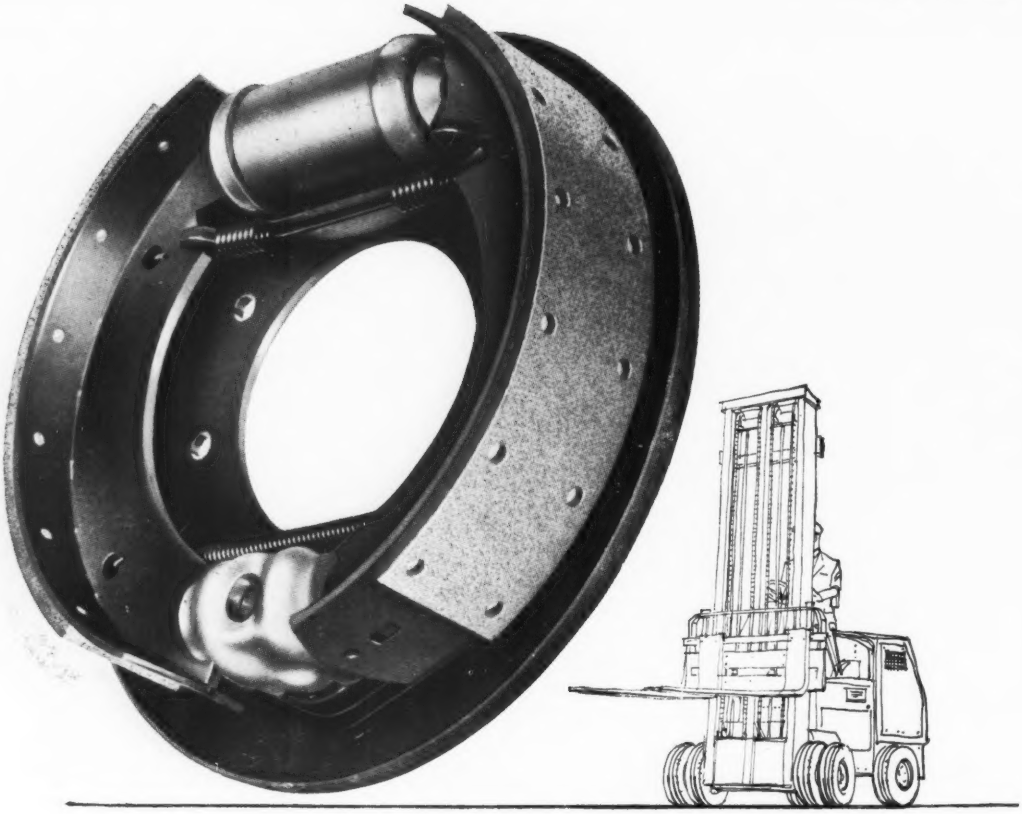
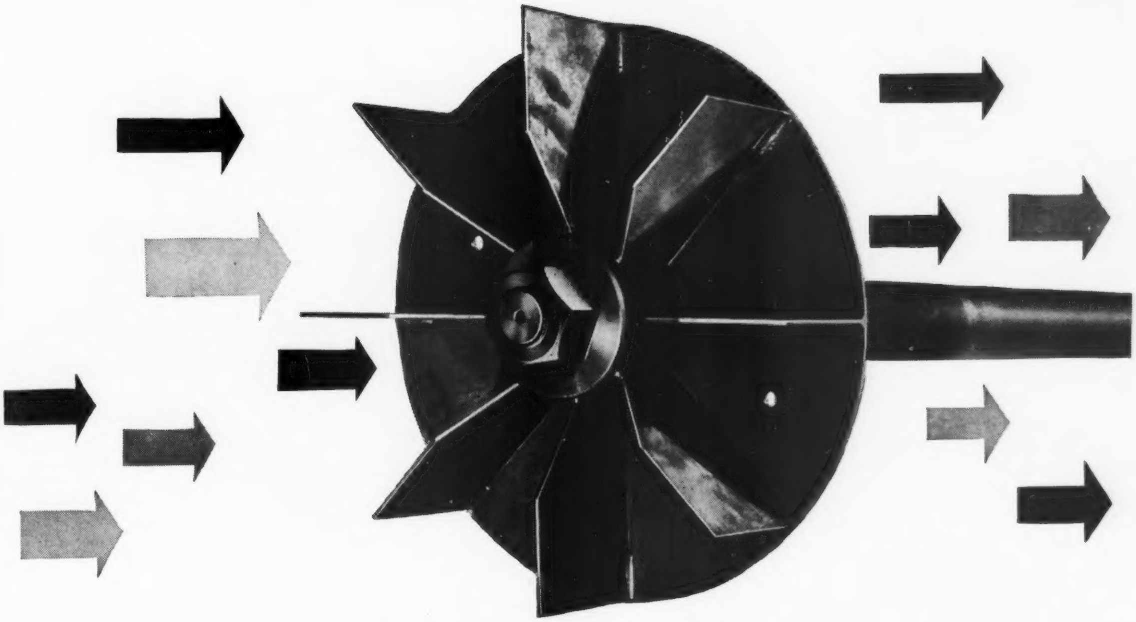
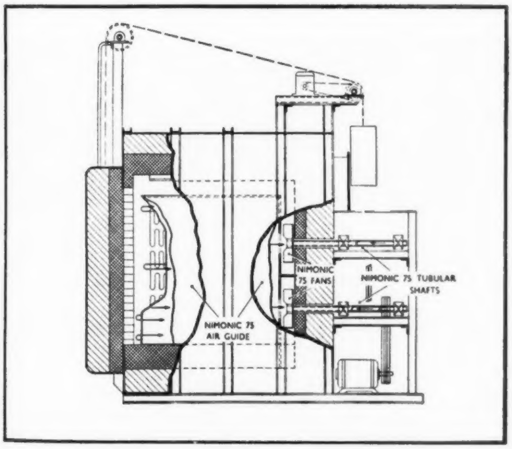




For furnace fans operating at 1100° C

-Nimonic* 75



HEAT-RESISTING ALLOY

A high-temperature electric furnace of advanced design has been developed by Hedin Limited, for the heat-treatment of components during the overhaul of Rolls-Royce 'Avon' and 'Conway' turbo-jet engines.

To ensure even heat distribution within the furnace, four centrifugal fans are required to operate continuously at temperatures up to 1100°C. The nickel-chromium alloy, Nimonic 75, was selected for the construction of the fans and their drive shafts. The excellent high-temperature properties of Nimonic 75 enable it to resist oxidation and withstand the exacting centrifugal stresses at extreme heat.

TOP
In addition to the forced-circulation fans and drive shafts, Nimonic 75 is used for the air-guide furnace liner which directs circulating air over the heating elements.

INSET
Diagram shows forced-circulation system and the Nimonic 75 hollow fan-shafts cooled by compressed air.

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TGA H16

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for choosing your temperature

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1100°	600°
925°	500°
750°	400°
570°	300°
400°	200°
212°	100°
110°	50°
32°	0°

Illustration shows Isotapes (before application of lagging) as installed by Babcock & Wilcox Ltd., at the Generating Station of the C.E.G.B. at Plymouth.

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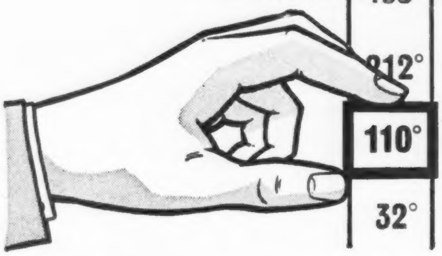

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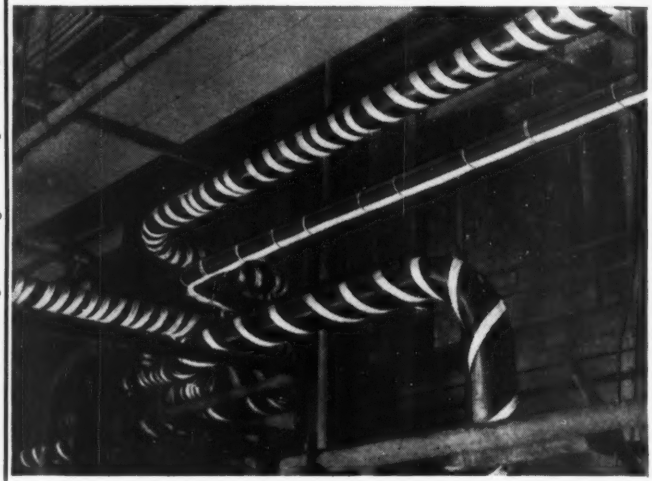

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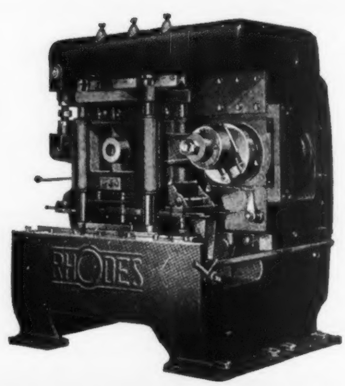

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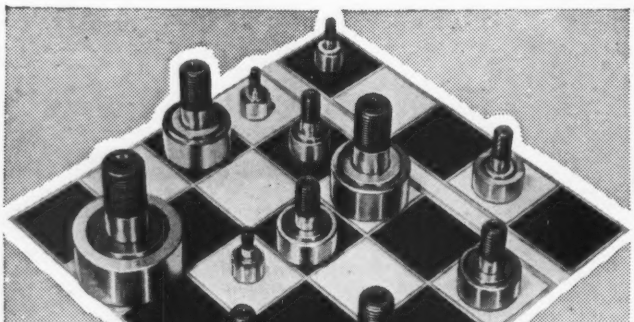

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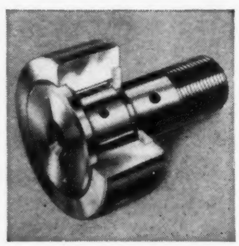

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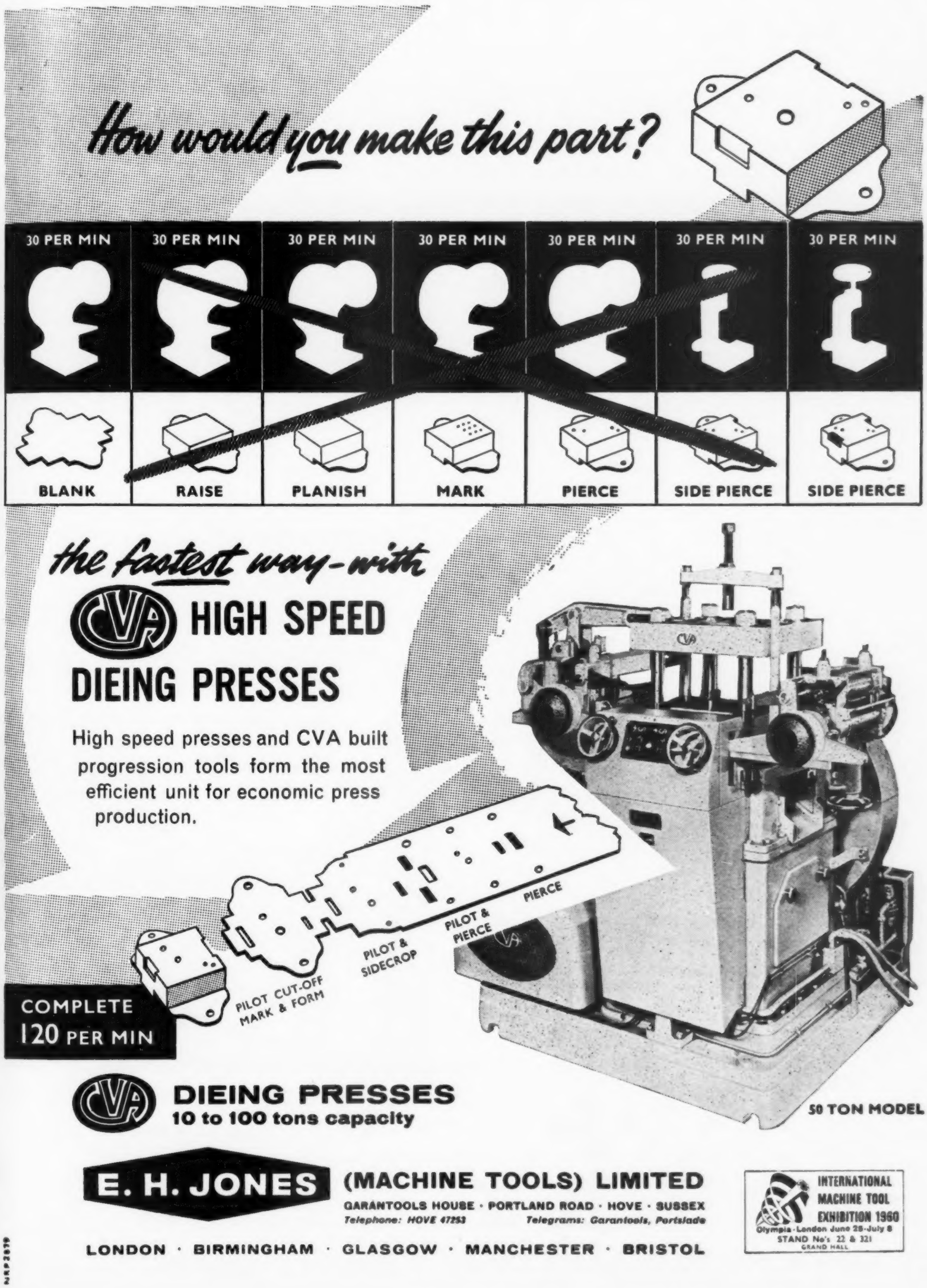
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30 PER MIN
30 PER MIN
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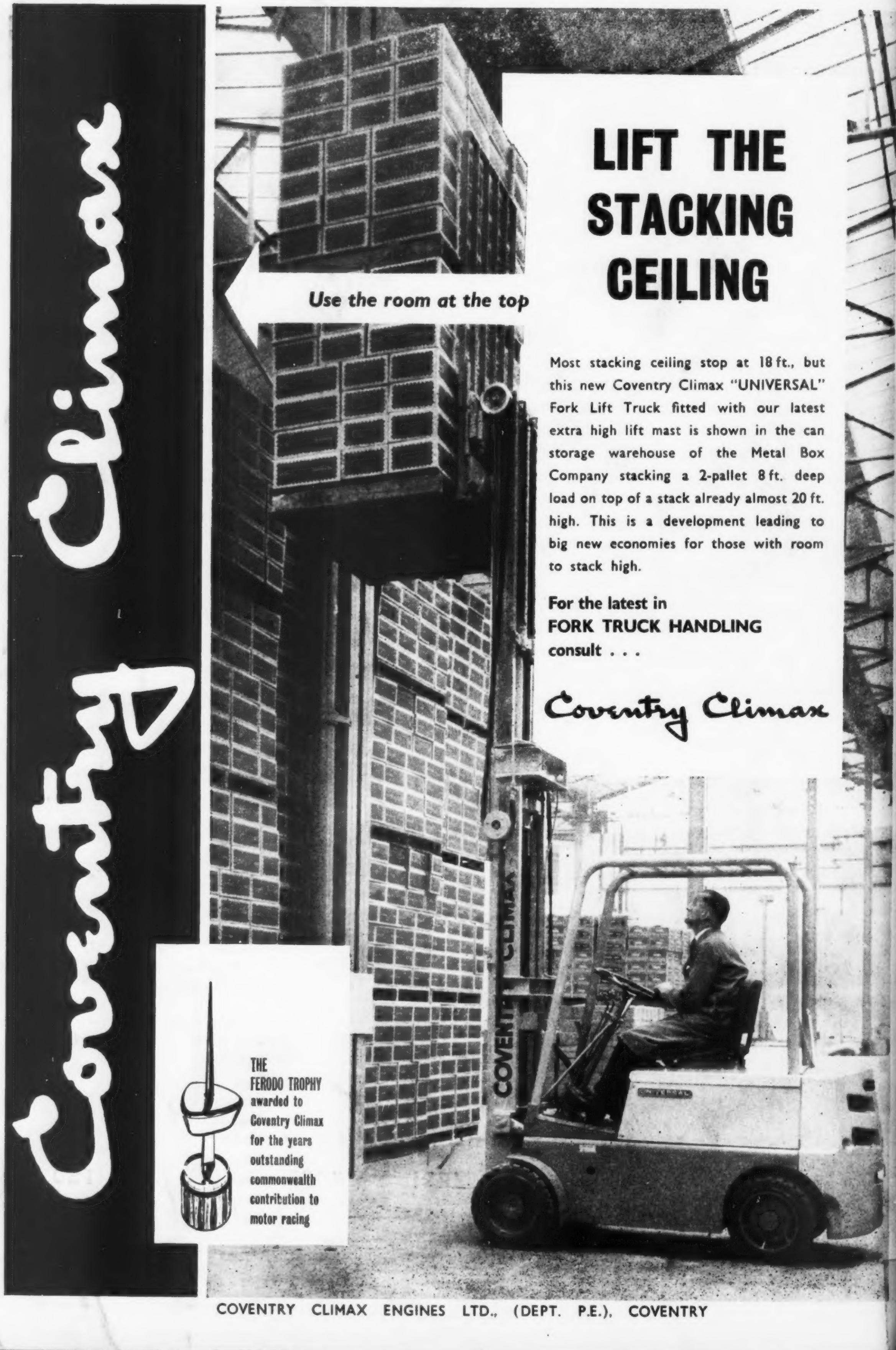
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